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Sponsored jointly by the Canadian Department of Labour and the U.S. Department of Labor, the Conference was held to examine the impact of automation on employment and unemployment, the nature of jobs being created and eliminated, and steps to be taken to ease the effect of technological change on workers. The participants were government, management, labor, and university representatives from North American U.S. and other Organization for Economic Co-Operation and Development countries. The U.S. Department of Labor papers are: (1) "Technological Change, Productivity, and Employment in the United States," by L. Greenberg, (2) "The Pace of Technological Change and the Factors Affecting It" by S.L. Wolfbein, (3) "Effects of Technological Change on Occupational Employment Patterns in the United States" by E. Clague, (4) "Effects of Technological Change on the Nature of Jobs" by L. Levine, (5) "The Labor Force Adjustment of Workers Affected by Technological Change" by R.C. Goodwin, and (6) "Implications for Government-Sponsored Training Programs in the U.S.A." by J.P. Walsh. The appendixes contain a bibliography of selected references and a list of all 16 technical papers presented at the Conference. (HC)

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MANPOWER IMPLICATIONS OF AUTOMATION

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U.S. DEPARTMENT OF LABOR
W. Willard Wirtz, Secretary
MANPOWER ADMINISTRATION
OFFICE OF MANPOWER, AUTOMATION AND TRAINING

SEPTEMBER 1965

PAPERS PRESENTED BY THE U.S. DEPARTMENT OF LABOR AT THE O.E.C.D. NORTH AMERICAN REGIONAL CONFERENCE ON

MANPOWER IMPLICATIONS OF AUTOMATION

WASHINGTON, D.C.
DECEMBER 8-10, 1964

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PREFACE

One of the chief thrusts of the 21-nation Organisation for Economic Co-operation and Development (OECD) is to aid its members in developing policies to facilitate the adjustment of the labor force to technical and structural change. As part of its function as a forum for the exchange of informed views on economic problems and policies, the OECD organized the North American Regional Conference on the Manpower Implications of Automation, held at the U.S. Department of State, in Washington, D.C., December 8–10, 1964.

Sponsored jointly by the Canadian Department of Labour and the U.S. Department of Labor, the Conference included participants from government, management, labor, and universities in North American and other OECD-member countries. The Conference examined the impact of automation on employment and unemployment, the nature of jobs being created and eliminated, and steps to be taken to ease the effect of technological change on workers. Technical papers on these and related subjects were presented by 16 experts from Europe, Canada, and the United States and will be published by the OECD during 1965. A list of these papers is presented in appendix B.

The purpose of this document is to publish the papers presented by the participants from the U.S. Department of Labor in a single volume as a record of the pooled knowledge and relevant experiences of Labor Department officials, and as possible guidelines for both national and international use in the effort to realize the full benefits of technological change at minimum human cost.

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TECHNOLOGICAL CHANGE, PRODUCTIVITY, AND EMPLOYMENT IN THE UNITED STATES

Leon Greenberg

Leon Greenberg, Assistant Commissioner, Bureau of Labor Statistics. Member, American Statistical Association; American Economic Association; and Committee on Technological Change and the Older Worker of the National Council on the Aging. Served as delegate to meetings of the International Labour Organisation and the Organisation for Economic Co-operation and Development. City College of New York (B.S.); graduate work, University of Michigan, New York University, the American University.

Technological change is not a new phenomenon unique to our modern economy. History is replete with accounts of new inventions, new products, and new processes. But this past history does not mean that there is nothing new about modern technology. While the rudiments of automation and other forms of current technology—in theory, invention, and specific cases of application—may often be traceable back for several decades, there could be important differences between modern developments and those of the past. The differences may arise from the relatively massive application of new techniques, from more rapid diffusion of all types of technology throughout the economy, and from the occupational impact of new technological developments on particular groups of workers whose opportunities for employment are disappearing.

It is this kind of technological application, in an economic environment of both high employment and high unemployment—at least in the United States—that has engendered so much study and controversy—both technical and emotional—over the impact on the worker.

To a man who has worked for a company for years, who sees a new machine brought in and who, soon thereafter, finds himself unemployed and looking for a job, the impact of technology is crystal clear—it has destroyed his job. To the economist who is trying to evaluate the impact of technology, it is also clear that, in many cases, new machinery results either in layoff of workers or reduced hiring of new workers. But the economist also has an obligation to consider the broad impact of technological change on the economy as a whole and to evaluate technology along with other factors which may affect employment and unemployment.

In the pursuit of these objectives, three major questions will be explored in this paper: (1) What has been the pace of technological change? (2) What is the relationship of technological change to employment and unemployment? (3) What are some factors affecting the outlook for the future?

In attempting to trace the complex relationships throughout the economy, aggregates and statistical averages are used. Such averages hide the changes and adjustments which affect many individual workers and, as indicated in the final section of this paper, their individual needs must not be overlooked.

Also, in attempting to deal with these issues, we face the common problem that precise and incisive answers are not always attainable. Frequently, the basic statistics needed to measure or evaluate are not available at all or are in short supply. The measurement of technology or technological change has conceptual as well as statistical difficulties. It is fairly common practice to use the productivity index, output per man-hour, as an indicator of technological change. But productivity is affected by various other factors—rate of investment, organization of workflow, scale of operations, availability and quality of raw materials, skill of management and the work force, and other variables. Nevertheless, an index of output per man-hour, in its inverse form, gives us a measure of change in labor requirements per unit of output. This measure is heavily affected by technology as well as some of the other factors, such as organization of work, which are often directly tied in with the introduction of new equipment. Within its limitations, output per man-hour is a useful indicator of the change in labor requirements associated with technological change.

THE PACE OF PRODUCTIVITY CHANGE

In studying the pace of productivity change, it is useful to first compare the postwar rate with previous long-term rates and then to examine the experience of recent years. (It should be kept in mind that productivity trends may be closely related to changes in volume of output, but this will be discussed in a later section.)

Long-run Versus Post-World War II Experience

The long-run rate of increase in output per manhour in the total private economy, covering the period 1909–63, is 2.4 percent per year.[1] The postwar rate is 3 percent a year. This latter rate compared with previous long-term trends represents a substantial increase in the rate of productivity gain; it compares with 2 percent for the period 1909–47 and 2.3 percent for the period 1919–47 (table I).

It may be argued that the long-run rate is influenced by the decline in productivity which occurred in the early years of the depression. That is true, but it is difficult to find any long, sustained earlier period (of 15 years or more) when the total private economy achieved an average productivity gain as high as 3 percent. In the decade 1919–29, when performance was relatively good and manufacturing showed very large increases, the average rate was about 2.9 percent. But that covered 10 years—less than the 16 thus far in the postwar period. For the 15-year period, 1930–45, the average increase was high, 3.4 percent. But this period starts at a depression low point and ends at a peak war year, so it is quite atypical and does not have general economic significance.

TABLE I.—*Average Annual Percent Change*[1] *in Output per Man-Hour, Output and Man-Hours—Total Private Economy, Agriculture and Nonagriculture, 1909–63 and Subperiods*

Sector and periods	Output per man-hour	Output	Man-hours
Total private:			
1909–63	2.4	2.9	.5
1909–47	2.0	2.4	.3
1919–47	2.3	2.7	.4
1919–29	2.9	4.5	1.6
1947–63	3.0	3.4	.4
1957–63	3.1	3.5	.4
Agriculture:			
1909–63	2.5	.8	−1.6
1909–47	1.3	.7	−.5
1919–47	1.7	.9	−.8
1919–29	1.1	1.1	0
1947–63	5.7	1.4	−4.1
1957–63	4.9	1.3	−3.4
Nonagriculture:			
1909–63	2.1	3.1	1.0
1909–47	1.9	2.6	.6
1919–47	2.1	2.9	.8
1919–29	2.7	5.0	2.2
1947–63	2.4	3.6	1.1
1957–63	2.8	3.6	.8

[1] Computed from the least squares trend of the logarithms of the index numbers.

SOURCE: Output based on U.S. Department of Commerce estimates of gross national product in 1954 dollars. Man-hours based primarily on establishment data. Includes man-hours of self-employed and unpaid family workers in addition to wage and salary workers.

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[1] Output data for the private economy and major sectors are based on constant dollar gross national product data published by the U.S. Department of Commerce.

The difference between a 2-percent and a 3-percent rate of change may look small—only one percentage point—but it represents a 50-percent increase over the average gain which the private economy was able to achieve in the previous long-term period. Even if compared with the 1919–47 rate of 2.3 percent, the difference is still 0.7 percent—a substantial relative gain when compounded over a large number of years.

In evaluating this increase in productivity rate, it is helpful to look at two major components of gross national product for which data are available—agriculture and nonagriculture—because of their differential movements over time, their impact on the overall productivity rate, and future implications.

Agriculture.—Much has already been written about the great productivity performance of the agricultural sector. Agricultural output per man-hour improved very slowly (less than 1 percent a year) in the years between 1909 and the mid-1930's, then picked up speed and in the 16-year period since 1947 has averaged 5.7 percent per year. The average rate for the period 1909–47 was 1.3 percent.

This sustained rise in agriculture is the result of several factors. One is improved technology, which has contributed via the use of farm machinery and the application of chemistry and biology to seed, soil, and insect pests. Also contributing has been the trend toward large-scale farming with its concomitant mass production techniques (as in chicken farming). A related factor has been the abandonment of small, less productive farms.

Thus, it can be seen that the substantially higher rates of gain in agriculture in the postwar period have had an important impact on overall rates of productivity growth. In addition, the shift of employment from the farm to industry (i.e., from low to high productivity sectors) has also contributed to the overall rate of gain. However, at this date, agricultural employment is a very small part of the total economy and its impact on the total can be expected to be less important than in the past.

Nonagriculture.—The 2.4 percent rate of increase in output per man-hour in the nonagricultural sector in the postwar period is also higher than previous long-term trends—1.9 percent for the period 1909–47, or 2.1 percent for the period 1919–47. These differences are not as great as for the total private economy. In addition, we find that the postwar gain is lower than the 2.7 percent average achieved in the decade 1919–29—a period in which there were no major wars or depressions. But here it is important to take cognizance of large differences in the change in volume of output, to which we will return in a later section.

The nonagricultural sector of the economy includes a heterogeneous mix of major industrial divisions, such as manufacturing, trade, service, and others. Data for these sectors for long-term or recent periods are often not available or not strictly comparable over time. However, available figures indicate that output per man-hour in manufacturing has gone up at a somewhat slower rate during the postwar period as a whole than for the previous long-term period (here, too, output may be a factor). On the other hand, if production workers only are included in these measures, then output per man-hour in the postwar period has gone up at a slightly higher rate than the previous long-term period—an illustration of the differential impact of technology.

Summary.—Output per man-hour in the total private economy has gone up at a more rapid rate during the postwar period than it did over the previous long-term period. A large part of this is accounted for by the agricultural sector, where very large gains have taken place in the last 16 years. Nonagriculture also shows a higher average increase than over the long term. The decade of the 1920's also stands out as a period of fairly rapid growth in productivity, but the relative changes in output have an important bearing on these trends.

Recent Trends

It is, perhaps, worthwhile to introduce a note of caution before discussing recent trends in productivity. Short-term changes may be influenced by a variety of factors, such as recession and recovery, rate of investment, scale of output, and others—similar to those influencing the long-run trends. However, it is difficult to evaluate the relative permanence of some of these factors and the extent to which short-term changes may be indicative of new trends. In addition, the statistics available to us are not as precise as we would like them to be and those for the most recent years are often

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subject to revision.[2] Further, two sets of productivity estimates are available, based on different employment and man-hour data—one from surveys of business establishments, the other from surveys of households—and they do not always yield identical results. The former will be used in this analysis (unless otherwise indicated), since it is available in more detail and permits some analysis of sectors within nonagriculture.

There was a surge in productivity in the early postwar years as output expanded to take care of the pent-up demand for goods. It slackened off during the 1950's and in more recent years has been rising more rapidly again. For the total private economy, output per man-hour rose about 3½ percent a year in the 3-year period 1960–63. Because of the precautionary note mentioned in regard to short-term changes, the significance of this figure is not yet firmly established. Extending the period back to 1957, the average rate of gain was about 3 percent, the same as the total postwar average.

If 5- (or 6-) year averages are traced back through the postwar period, we find that most of the time the rate was 2½ percent or better. Only once was it less than this, and then it was 2.4 percent.

In agriculture, the spectacular rate of increase seems to have slowed down a bit, although it is still high. The average gain in the last 6 years was 4.9 percent compared with the postwar average of 5.7 percent. This declining rate, plus the declining effect of shifts from agriculture to industry, have had a somewhat dampening effect on the overall indexes.

In nonagriculture, the increase in the last 6 years has averaged better than 2½ percent a year. Comparison with the postwar period as a whole is uncertain because somewhat different results are obtained depending on which series of labor input data is used.

Data on manufacturing are preliminary; the indications are that the 1957–63 period will show a higher rate of increase than the postwar period as a whole.

The above findings are approximately consistent with an analysis of the Council of Economic Advisers, which concluded:

> To determine whether these relatively larger gains of the past 3 years exceed past trends, it is necessary to sort out the cyclical and transitory factors affecting productivity. For this purpose, several alternative statistical analyses were undertaken on the nonfarm productivity gains of 1949–60. . . . These findings were then used to estimate the productivity gains that might have been expected in the years 1961 through 1963 if the past relationships and trends still held.
>
> Depending on which statistical analysis is used (and there is no clear basis for preferring one to another), the *recent gains are either about in line with the expectation or exceed it by amounts ranging up to 1 percentage point.* . . . If objective analysis does not support a firm conclusion that the trend of productivity has accelerated, neither can that possibility be dismissed. Technological progress may indeed have accelerated, but its impact on productivity may be only gradually becoming visible because of the time that must elapse before innovations become embodied in new capital equipment and expressed in new organizational forms.[3]

THE RELATIONSHIP OF PRODUCTIVITY AND EMPLOYMENT

Most people will agree that, in the long run, improved technology and higher productivity have brought material benefits to the American worker and his family. Technology in the form of new products and materials has eased the drudgery of household work, improved the comfort and durability of the clothes we wear, brought fast transportation to millions of travelers by automobile or airplane, and has in many other ways improved our health and span of life.

Increased productivity has also made it easier to purchase these former luxuries—as well as the basic necessities of food, clothing, and shelter—by reducing costs and raising the real income of workers. It has enabled the work force to shift from the production of one type of goods or services to provide new goods and services to themselves and many others. And it has provided the means for increased leisure. A simple and, by now, classic example is agriculture—one farm worker in the United States now grows enough food and fiber to supply about 29 persons, compared with 7 persons 50 years ago.[4]

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[2] The series on gross national product may be revised back to 1947 by the U.S. Department of Commerce as a result of work now underway involving a new benchmark, new data, and shifting to a 1958 price base.

[3] *Economic Report of the President* (Washington: U.S. Council of Economic Advisers, January 1964), p. 97.

Along with these developments of higher standards of living, we have had increasing employment. Productivity today is more than three times as high as it was 50 years ago; employment is more than one and one-half times as high. Of course, we have a larger population and today about 5 percent of the labor force is unemployed. And here is where the second question begins. Are modern technology and productivity responsible for or closely related to our high rates of unemployment?

We have already seen that the postwar rate in output per man-hour is higher than that of the long-run trend. The rate for the last few years is also higher, but whether or not it is now moving at an even more rapid rate is not yet firmly established. As will be seen later, employment and unemployment have not always moved in accordance with productivity changes. Obviously, there is another variable to be considered, as mentioned earlier, and that is the rate of change in output.

With this third variable, the questions are rephrased: Is productivity now advancing more rapidly relative to output, so that it is resulting in decreases (or smaller increases) in employment? Is the long-run trend relationship changing or are there short-run relationships between productivity, output, and employment which are different from those of the long run? These three variables are not independent of each other and statistical analysis is hampered by the fact that productivity is the ratio of the other two variables—output and input—with which it is being compared. And even if statistical relationships can be measured in some way, how can we be sure which is the cause and which the effect? These kinds of problems show up in attempting long-run comparisons. We have had two major wars and a major, long-lasting depression in the last 50 years. They have affected the variables we seek to analyze, in different ways at different times.

With some precautions in mind, let us reexamine the trends, both long term and short run. Reference will be to total employed man-hours rather than employment, because the latter is also affected by changes in average annual hours.

Long-run Comparisons

Apparently, the long-run relationship between productivity and output (and, therefore, employment) has not changed very much. The difference between these two variables was roughly the same for the periods 1909–47, 1919–47, and 1947–63. Man-hours rose about 0.4 percent a year during these periods.

The relationship between these variables has differed for major sectors of the economy, which have contributed to the trends in different ways.

In agriculture, employment has been declining for years. However, the postwar ratio of productivity to output is much higher than that of the past and the rate of decline in employed man-hours is also high—4.1 percent for the period 1947–63 compared with an annual decline of 0.5 percent for the period 1909–47. Many of the workers who left the farm and obtained jobs in industry are unskilled workers. However, the statistics on unemployment do not indicate how many of the large number of unemployed, unskilled workers were recent farm migrants.

A different relationship has existed in the nonagricultural sector as a whole. Here, over the last half century, output per man-hour has gone up at a lower average rate than output and man-hours on the average have increased. The ratio between the two variables is a little lower for the postwar period as a whole than that for the previous long run, so man-hours employed have gone up at a faster rate.

In manufacturing, over the long run (1909–47), the average annual increase in productivity (all employees) was somewhat higher than the average increase in output and there was a small annual decline in total man-hours. The reverse was true for the postwar period, when there was an average annual increase in man-hours. However, a somewhat different pattern prevailed for production workers only; productivity went up more than output for the long-run and postwar periods, with the margin between productivity and output roughly the same for both periods, and with declining average employed man-hours.

There is some difficulty in interpreting the significance of these relationships between the postwar and previous long-run periods because the two periods are so dissimilar. For example, output dropped precipitously in the depression of the 1930's, then rose again, but by 1939 it had just about regained its 1929 level. In contrast, productivity increased during most of this period and by 1939 was higher than in 1929 (about 18 percent for total private and nonagriculture; more than 25 percent for manufacturing). Consequently, there was a sharp drop in employed man-hours from 1929 to 1939. These changes are reflected in the long-term averages.[5]

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[4] *Changes in Farm Production and Efficiency*, Statistical Bulletin 233 (Washington: U.S. Department of Agriculture, 1963), table 22.

A different picture emerges when one examines the decade 1919–29, an economic period which bears greater similarity to the postwar period than does the whole sweep of years 1909–47. In that decade productivity and output both rose at a rather good rate. For the private economy, productivity rose 2.9 percent a year and output 4.5 percent. Employed man-hours increased 1.6 percent a year. For nonagriculture, productivity went up much less than output during the 1919–29 decade and man-hours increased more than 2 percent a year—twice as fast as during the postwar period. In manufacturing, productivity and output increased at about the same rate and there was very little change in man-hours.

Summary.—The postwar period does not appear to be substantially different from the previous long-term period in terms of the relationship between productivity and output for the total private economy. Because of the similarity in these relationships, employed man-hours changed at about the same average rate during both periods. The trends for the agricultural and nonagricultural sectors differed, with the former showing declining man-hours for many years and the latter showing average increases. However, the war and the depression had a substantial influence on the long-term trends. In contrast, during the decade of the 1920's, when the rates of productivity gain in the private economy and in nonagriculture were about as high as for the total postwar period, output went up at a much faster rate—so that employed man-hours rose at a much faster rate in that decade than during the postwar period.

Recent Experience

We turn now to the question of whether the relationship between productivity, output, and employment has been changing during recent years (tables I and II).

Output per man-hour in the last 6 years (1957–63) has gone up at about the same rate as for the postwar period as a whole. The changes in output are also similar for the two periods. Consequently, man-hours employed have gone up at about the same rate during the last 6 years as for the postwar period as a whole (based on establishment data).

In agriculture, output has been increasing at about the same rate as the average for the postwar period, but the rate of productivity gain has fallen off a bit. Man-hours are still declining but at a less rapid rate. In nonagriculture, the pattern is roughly similar to that for the total private economy.

In manufacturing, productivity and output have both increased more in the last 6 years (1957–63) than for the postwar period as a whole, but in slightly different proportion. Employed man-hours have increased at a slightly lower rate in the last 6 years than during the entire postwar period.

There is another interesting facet to the comparison of productivity and output, relevant to both the analysis of past trends and possible implications for future developments. It is fairly well known that, on an annual or shorter term basis, productivity changes are usually highly correlated with changes in output. But what is the constancy of the productivity-output relationship? Does the change in productivity bear a constant relationship to the change in output, no matter how large or how small the output change?

On an overall basis, annual changes in output per man-hour as a function of changes in output have, as expected, a positive correlation. For the total private economy, the correlation is about 60 percent or more for the postwar period as a whole and for the period 1957–63. For the nonagricultural sector, the postwar correlation is not quite 60 percent but rises to 80 percent or more if only the last 6 years are used. Preliminary data for manufacturing indicate correlations similar to those of the nonagricultural sector.

If the annual changes (in index number form) are arrayed, there seems to be a declining ratio of productivity to output, i.e., the larger the increase

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[5] The long-term averages are based on the least squares method of calculation, which average out the fluctuations occurring in each year of the period studied. They are therefore affected by the downturn of the depression of the 1930's and the subsequent recovery. If only terminal years are considered, as in compound interest computations, the results would be different, since employed man-hours were actually higher in 1947 than in 1909 or 1919.

TABLE II.—*Indexes of Output per Man-Hour, Output and Man-Hours—Total Private Economy, Agriculture and Nonagriculture, 1947–63*

[1957–59=100]

Year	Output per man-hour			Output			Man-hours		
	Total private	Agri-culture	Nonagri-culture	Total private	Agri-culture	Nonagri-culture	Total private	Agri-culture	Nonagri-culture
1947	70.9	50.2	76.3	68.4	81.2	67.7	96.5	161.8	88.7
1948	73.4	59.6	77.9	71.2	92.8	70.0	97.0	155.8	89.9
1949	75.5	56.8	80.8	70.8	88.0	69.8	93.8	154.8	86.4
1950	80.9	64.7	85.1	77.3	92.8	76.4	95.6	143.4	89.8
1951	82.9	64.0	86.5	82.0	87.0	81.7	98.9	136.0	94.4
1952	84.7	69.9	87.6	84.4	90.4	84.1	99.6	129.4	96.0
1953	88.2	77.8	90.0	88.6	93.7	88.3	100.5	120.5	98.1
1954	89.8	83.4	91.4	87.2	97.6	86.6	97.1	117.0	94.7
1955	93.8	86.4	95.3	95.0	102.9	94.5	101.3	119.1	99.2
1956	93.9	88.3	94.9	97.0	100.5	96.8	103.3	113.8	102.0
1957	97.2	94.2	97.6	98.9	99.0	98.9	101.7	105.1	101.3
1958	99.6	103.0	99.4	97.0	100.5	96.8	97.4	97.6	97.4
1959	103.2	102.8	103.0	104.1	100.0	104.3	100.9	97.3	101.3
1960	105.2	109.3	104.6	106.8	104.8	106.9	101.5	95.9	102.2
1961	108.7	115.8	107.6	108.6	104.3	108.8	99.9	90.1	101.1
1962	112.9	119.7	111.7	115.3	105.3	115.9	102.1	88.0	103.8
1963	116.8	128.5	115.0	120.0	107.2	120.7	102.7	83.4	105.0

SOURCE: Output based on U.S. Department of Commerce estimates of gross national product in 1954 dollars. Man-hours based primarily on establishment data. Includes man-hours of self-employed and unpaid family workers in addition to wage and salary workers.

in output, the smaller the *relative* increase in output per man-hour (tables III and IV).

When a regression equation is fitted to the data, the declining ratio of productivity to output shows up more sharply. For example, according to the regression equation, if output in the total private economy goes up 1 percent, the computed output per man-hour increase is 2.4 percent—and the ratio of productivity gain to output gain is 1.014. If output goes up 5 percent, the computed output per man-hour increase is 3.6 percent and the ratio is 0.987. The relationships are quite similar for the nonagricultural sector and for manufacturing (based on preliminary data). If the productivity-output ratio is greater than 1, it means that man-hours have declined; if the ratio is less than 1, it means that man-hours have increased.

The significance of these relationships may be apparent. Productivity of the private economy rarely declines—it usually goes up. In years when output has declined or moved up slowly, productivity has tended to pursue its usual upward proclivity and has usually exceeded the output increase. In those years, total man-hours decreased. However, when output moved up more rapidly, productivity, while still increasing, did so at a less rapid rate than output, and man-hours increased.

We have also correlated annual changes in output per man-hour directly with employment. The correlations are substantially lower than those for productivity and output, but still positive. For the postwar period the ratio is about 20 to 40 percent for the total private economy (depending on use of establishment or labor force series), but lower for nonagriculture and manufacturing. All the ratios are higher (40 percent or more) for the recent period 1957–63. These ratios may be affected by changes in average hours and by short-term business cycle fluctuations.[6]

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[6] Further exploration of these relationships would be useful—quarterly data or longer time periods, such as 3-year moving averages, might put the figures in sharper perspective. It is also possible that there is some lag between the productivity and employment changes.

Table III.—*Relationship Between Changes in Output and Output per Man-Hour,*[1] *Total Private Economy, 1948–63 and Computed*

Year (output in ascending rank order)	Output	Output per man-hour	Ratio of output per man-hour to output
	Actual		
1958	98.1	102.5	1.045
1954	98.4	101.8	1.035
1949	99.4	102.9	1.035
1961	101.7	103.3	1.016
1957	102.0	103.5	1.015
1956	102.1	100.1	.980
1960	102.6	101.9	.993
1952	102.9	102.2	.993
1963	104.1	103.5	.994
1948	104.1	103.5	.994
1953	105.0	104.1	.991
1951	106.1	102.5	.966
1962	106.2	103.9	.978
1959	107.3	103.6	.966
1955	108.9	104.5	.960
1950	109.2	107.2	.982
	Computed[2]		
	100.0	102.1	1.021
	101.0	102.4	1.014
	102.0	102.7	1.007
	103.0	103.0	1.000
	104.0	103.3	.993
	105.0	103.6	.987
	106.0	103.9	.980
	107.0	104.2	.974
	108.0	104.5	.968
	109.0	104.7	.961
	110.0	105.0	.955

[1] Changes in output and in output per man-hour expressed in terms of index numbers (previous year equals 100.0).

[2] Computed changes in output per man-hour and ratios of output per man-hour to output are calculated on the basis of hypothetical output changes and a regression equation derived from the actual changes in output and output per man-hour.

Table IV.—*Relationship Between Changes in Output and Output per Man-Hour,*[1] *Nonagricultural Sector, 1948–63 and Computed*

Year (output in ascending rank order)	Output	Output per man-hour	Ratio of output per man-hour to output
	Actual		
1958	97.9	101.8	1.040
1954	98.1	101.6	1.036
1949	99.7	103.7	1.040
1961	101.8	102.9	1.011
1957	102.2	102.8	1.006
1956	102.4	99.6	.973
1960	102.5	101.6	.991
1952	102.9	101.3	.984
1948	103.4	102.1	.987
1963	104.1	103.0	.989
1953	105.0	102.7	.978
1962	106.5	103.8	.975
1951	106.9	101.6	.950
1959	107.7	103.6	.962
1955	109.1	104.3	.956
1950	109.5	105.3	.962
	Computed[2]		
	100.0	101.8	1.018
	101.0	102.0	1.010
	102.0	102.2	1.002
	103.0	102.4	.994
	104.0	102.7	.988
	105.0	102.9	.980
	106.0	103.1	.973
	107.0	103.3	.965
	108.0	103.5	.958
	109.0	103.7	.951
	110.0	103.9	.945

[1] Changes in output and in output per man-hour expressed in terms of index numbers (previous year equals 100.0).

[2] Computed changes in output per man-hour and ratios of output per man-hour to output are calculated on the basis of hypothetical output changes and a regression equation derived from the actual changes in output and output per man-hour.

Comparisons have also been made between changes in output per man-hour in total manufacturing (preliminary data) with layoff rates (all employees). If productivity increases were to result in significant labor displacement, we would expect layoff rates to go up as productivity rises. The correlation between these two variables, on an annual basis, is close to zero—that is, there is no constant relationship. We have also used a lag analysis, relating the change in output per man-hour for each year to the layoff rates for the previous year. There is a fairly wide scatter of points, but there is a small positive correlation of about 40 percent. These figures are, of course, influenced by the business cycle—as output drops, workers are laid off but in the recovery period, while layoffs may decline, productivity tends to rise more rapidly.[7]

Summary.—This analysis indicates that, for the private economy as a whole, annual productivity gains during the postwar period tended to be accompanied by gains in output and, to a lesser degree, by gains in employment. Thus, these figures (as well as those for the long run) confirm a position long taken by many economists, that improved productivity and economic growth tend to go hand in hand. The data also indicate that the pace of productivity increase relative to the gain in output has not changed very perceptibly for the private economy during the postwar period. However, some slight change appears to have occurred in the manufacturing sector.

DISEMPLOYMENT IN MANUFACTURING INDUSTRIES

The impact of technological change on job or worker displacement is not adequately measured by aggregate figures on productivity and employment. Actual job displacement depends on the extent to which productivity gains are, or are not, matched by output increases at the lowest level of economic activity.

One could, for example, begin with a minute examination of specific technological changes at each work station or department in an establishment in order to measure displacement. In many such cases, workers may be displaced from a specific job, but they are transferred to other jobs and are still employed within the same firm. Such within-plant displacement may create some problems for some individual workers but, since these workers are taken care of within the plant, there is no unemployment. It seems more useful to consider the external displacement associated with technological change; that is, to examine employment changes on a plant-by-plant basis and see how they are related to productivity.

It also seems reasonable to assume that in a plant where employment has increased there is no net technological displacement, i.e., no disemployment, whether productivity has increased or not. This may not be true if certain kinds of workers are being displaced (e.g., blue-collar workers) while others are being hired (e.g., white-collar workers). Therefore, it is more informative to do the analysis separately for production workers. It is possible that some blue-collar workers are being displaced while others are being hired, but this would be an unusual situation. In any case, this is not likely to occur often enough to affect the statistical results. To repeat, in a plant where production-worker employment has increased, it is not unreasonable to assume that there is no disemployment.

Where employment has declined, such decline can be associated with higher productivity or with lower output. The former association may be viewed as disemployment. It should be recognized that changes in output may also reflect technological change—the substitution of a new material or product for an old one—resulting in increased employment in some industries but declining employment in others. At the same time, decreases in industry employment do not necessarily mean that workers are laid off and become unemployed. In some cases, employment reductions are achieved through normal attrition—deaths, retirements, and quits.

The results of detailed plant-by-plant analysis have, thus far, not been available, although some exploratory research work has been started. Meanwhile, an intermediate type of analysis has been made—examination of the productivity-output-employment relationship among individual industries in manfacturing—based on samples of 200 or more industries. The analysis has been carried out for four time periods, with some overlapping in each case (table V).

Industries were divided into groups according to whether they experienced increases or decreases in employment. The latter were allocated to output decreases or output per man-hour increases (in some cases to both).[8]

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[7] Separate analyses for production workers only and comparing rates by industry (rather than annually) would also be desirable.

[8] Actually unit man-hours (i.e., man-hours required per unit of output), the inverse of output per man-hour, were used. The use of this inverse was necessary for direct comparison with percent changes in employment. For example, a 20-percent increase in output per man-hour is equivalent to a 17-percent decrease in unit man-hours; the latter can be directly related to the percent decrease in employment.

Table V.—*Relationship Between Changes in Output per Man-Hour and Employment—Manufacturing Industries, all Employees and Production Workers, Selected Periods, 1947–62*

Item	All employees				Production workers			
	1947–57	1953–59	1957–61	1957–62	1947–57	1953–59	1957–61	1957–62
Average annual percent change [1] in—								
Output per man-hour [2]	2.7	2.4	2.1	2.8	3.5	3.4	3.1	3.4
Output [2]	3.5	1.4	.9	2.6	3.5	1.4	.9	2.6
Average annual change in industry employment (in thousands): [3]								
Net change	(4)	−162	−235	−105	75	−237	−273	−151
Increases	(4)	109	157	170	186	64	80	96
Decreases	(4)	−271	−392	−275	−111	−301	−353	−247
Associated with increases in output per man-hour	(4)	−131	−197	−174	−88	−188	−199	−172
Associated with decreases in output	(4)	−140	−195	−101	−23	−113	−154	−75

[1] Computed by the compound interest method. The least squares method is usually employed to calculate average annual changes in productivity and output but since the changes in industry employment were derived by using terminal years only, the compound interest formula (which also uses terminal years) was used throughout for this particular analysis.

[2] Based on U.S. Department of Commerce, OBE output data, and U.S. Department of Labor BLS man-hours. While these figures are not entirely consistent with the Census employment data used in industry analysis shown below, the differences are very small for the last three periods; for the 1947–57 period, the output per man-hour change would be somewhat smaller if based on Census data.

[3] The detailed industry analysis is based on output and employment data from the Bureau of the Census.

[4] Not available.

Production Workers.—It is clear that disemployment occurred among many industries, not only in periods when total manufacturing employment (of production workers) declined but also in those periods when it increased. However, the annual rates of disemployment varied among the four periods studied.

Output per man-hour increased at roughly the same annual average rate in each of the periods, ranging from about 3.1 to 3.5 percent. But in the first period (1947–57) output went up about the same as productivity; in the latter periods output went up much less than productivity. The disemployment figures—associated with productivity or output—are substantially less in the first than in the latter periods.

Some interesting changes occur when the year 1962 is added to the 1957–61 period. Productivity and output both increased substantially in 1962. As a result, productivity and output both increased more from 1957 to 1962 than from 1957 to 1961 (average annual rates) and employment declined at a lower rate in the latter period. However, the productivity-disemployment figure did not change very much; the bulk of the changes occurred among industries with employment increases and among those with employment decreases associated with declines in output. A similar relationship is shown in the comparison of 1947–57 with 1953–59. In the early period there was a net increase in employment; in the latter period a substantial decrease. The annual rate of productivity-disemployment was about doubled between the two periods while the annual rate of output-associated employment decline was about five times as high.

All Employees.—As indicated earlier, there may be a differential impact of technology on blue-collar and white-collar workers. This shows up through the simple expedient of comparing employment trends between the two groups. It is also evident in the disemployment figures which are available for three of the periods studied. The disemployment of all employees was less than that of production workers alone in the period 1953–59; the two figures were approximately equal in the 1957–61 and 1957–62 periods. The decrease in employment associated with decrease in output, however, was higher for all employees than for production workers in all three periods.

Dispersion of Disemployment.—The preceding analysis shows that disemployment occurs among manufacturing industries during periods of low as well as high overall gains in manufacturing productivity. There is still a question as to the type of industry in which disemployment tends to occur. To explore this question, the changes in productivity were correlated with the changes in employment (for production workers)[9] among the individual industries, between the first and last years of each of the time periods studied. In each of the periods the industry-by-industry comparison resulted in a negative correlation between changes in employment and changes in productivity—but the correlation ratios were low, ranging from 5 to 25 percent. The low correlation indicates that, on the average, productivity gains among industries were associated with both increases and decreases in employment over a period of years. Put another way, employment decreases occurred in industries with large productivity gains and those with small (or no) productivity gains. In the latter case, the declines in employment were associated with decreases in output.

There was, apparently, no special concentration among the industries of disemployment. All types of industries experienced this employment-productivity relationship—durables and nondurables—food, textiles, metalworking, machinery, and others. They included small and large industries, ranging from those which had fewer than 5,000 employees to those with over 500,000.

The industries with employment increases and those where the employment decreases were associated with decreased output also varied. They included durables and nondurables, cutting across almost all of the major industry groups, and ranged from small to large.

Qualifications of Industry Disemployment Analysis

The term "disemployment" has been used to refer to those declines in industry employment associated with increases in productivity (or the declines in unit man-hours). Quite clearly, some decreases in employment are associated with declines in output and not with productivity change. Probably in many cases the decline in output and employment among plants and industries was due to technological substitution—for example, the replacement of coal by oil, natural fiber by synthetic fiber, rail transportation by the automobile, metals by plastics. This kind of change does not show up in the productivity figures, except insofar as industries which use the new materials or products increase their efficiency as a result of such substitution.

The figures reflect only net disemployment *between industries.* They are the net result of changes in employment occurring among many plants—some with increases, others with decreases—and may not reflect the sum total of disemployment which took place among all plants. For example, in those industries where employment increased, there were probably a number of plants in which employment declined. In these cases, while job opportunities in the industry as a whole did not decline, the occupations and their locations may have changed.

It is also possible that the method of analysis, using the net change between terminal years, could mask disemployment that may have occured during the intervening years. On the other hand, the choice of too short a period of time may pick up employment decreases which are only temporary.

Summary.—This analysis strikingly illustrates the differential impact of technological change on different industries in the manufacturing sector of the economy. It also illustrates how trends in output are of major importance in evaluating the employment effects of technological change. For each of the periods studied, if comparisons are made industry-by-industry, there seems to be no consistent pattern relationship between changes in productivity and changes in employment. And yet, in each period there was a substantial volume of employment decline in many industries associated with increases in productivity. Also, there were many other employment decreases associated with decreases in volume of output; some of the latter were, undoubtedly, the result of technological changes involving new products or new materials. The total volume of employment decrease among industries seems to be at least partly affected by the change in output for manufacturing as a whole. At the same time, the net change in manufacturing employment does not indicate the total volume of disemployment which may occur at any one time.

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[9] To a certain extent, the relationship between productivity and employment changes is affected by changes in annual hours worked, but, on the average, this was not significant during this period.

A major current-day question is whether the postwar rate of productivity will continue or accelerate over the next few years. While it is not the purpose of this paper to forecast future trends in productivity and employment, some of the factors which may affect such trends are discussed in this section. They include technology, research and development, and investment.

As suggested earlier, much depends on the growth rate in output for the economy as a whole. In addition, changes in the composition of the Nation's output may also affect the productivity trends. Services such as medical care, education, hotel service, personal care, and repair services involve custom work, and mechanization of these activities is inherently difficult. Future shifts to services are difficult to measure precisely, but if they grow in relative importance it may be presumed that the effect would be to have some retarding influence on overall productivity advances for the total economy.

Over the long run, the rate of productivity growth depends on scientific and technical advances that result in ways of producing goods and services more efficiently or in new products and services. It is useful in assessing the outlook, therefore, to review some sources of technical progress. An extensive study of such sources would need to discuss changes in such intangible factors as attitudes toward science and invention, institutional barriers and incentives to innovation, etc. In the absence of a discussion of these trends, we must assume that the framework that has existed in the past 15 years will remain substantially unchanged.

Technological Developments

It is not too difficult to discern that we are in an era of technology which is different in certain respects from that of the past. Our everyday life today is much more technologically oriented—and sometimes regulated—than it was 50 or even 15 years ago. In the early days of industrialization, technology took the form of transfer from hand to machine labor. At a later stage, mass production and mass assembly techniques came into prominence. New materials and products were developed all during these periods. Today we are in an age of modern science, with exotic types of technologies which may come to have wide applicability in many different industries. The laser, the fuel cell, nuclear energy, while still in a developmental stage, have enormous potentiality for changing industrial processes.

One form of modern technology—automation—is already spreading rapidly throughout many industries. The electronic computer for mass data processing and analysis has mushroomed from about 100 installations in 1954 to 12,000 installations in mid-1963, according to unofficial estimates.[10] Other applications involving the principle of communicating information or instructions are being rapidly developed—numerical control of machine tools, process control, warehousing, and elsewhere. This type of communication and control, not only man to machine, but also from machine to machine, is likely to continue its rapid development for some years to come and is likely to have a major impact on the economy. What is less certain is just how rapid this development will be and whether the impact will be felt suddenly or more gradually over a period of years.

During this past year, the Department of Labor published a report which reviewed briefly the technological developments in 36 manufacturing and nonmanufacturing industries.[11] The developments described are past the drawing-board stage; they are already in use to some degree and are spreading to other plants or offices.

It is clear from this report that in industry after industry major changes are already occurring. In air transportation and railroads; in banking and insurance; in trade and textile factories, modernization, automation, and various other forms of technological changes are taking place. New products may have an important laborsavings impact on some industries, while creating employment in others. If we could add up, in some way, these technological changes and their potential impact on employment, we might arrive at some frightening conclusions about mass displacement of workers. It would be a mistake, however, to reach such conclusions by paying attention only to

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[10] Based on special report prepared by the Diebold Group, Inc., for the Office of Manpower, Automation and Training, Manpower Administration, U.S. Department of Labor.

[11] *Technological Trends in 36 Major American Industries*, Prepared for the President's Committee on Labor-Management Policy (Washington: U.S. Department of Labor, Bureau of Labor Statistics, 1964).

those areas where dramatic or rapid or otherwise important kinds of technological changes are occurring. While new technology may spread very rapidly in some industries, it does not follow that at the same time there will be new technological changes spreading rapidly in all other industries. In other words, also important is the timing and dispersion of technology among plants and industries throughout the economy. In fact, if the 36 industries are examined in terms of their total employment outlook, we find a mixed package—some are expected to increase employment, some to decrease it, and some to remain unchanged. Thus, there arises again the difference between total or average trends and the diversity of change and impact among the many segments of the economy.

Research and Development

One reason often given for assuming a faster pace of technological change in the coming decade is the impressive recent growth of research and development. Expenditures for R&D in 1962–63 amounted to $16.4 billion, or three times the amount for 1953–54.[12] Part of the change reflects a rise in salaries of engineers and scientists and probably in the amount and price of equipment and materials used in research. The number of scientists and engineers engaged in R&D work nearly doubled in the past decade and now stands at more than 450,000.[13]

While the stockpile of scientific knowledge and technical developments has undoubtedly expanded, the implications for productivity and technological change in the economy as a whole are not yet fully apparent. The great bulk of R&D is conducted for defense and space programs and may only secondarily improve the performance of industries not related to these government activities. Only a small portion—13 percent in 1962—was devoted to research on new processes that might contribute to greater productivity;[14] most R&D is for new and improved products. Because of the concentration of research in only a few defense- and space-related industries and in large companies, the Federal Government is giving attention to measures for adapting military research to civilian uses and stimulating greater R&D among industries that have not benefited from space and defense programs. The results of such limited activities remain to be seen.

Investment

While the growth of R&D enlarges the potentialities for technological advance, the introduction of new processes and products in industry requires investment in plant and equipment. Such expenditures, whether for modernization or replacement, offer opportunities for installing the latest available equipment and machinery and thereby improving productivity.

Current data indicate that industry is significantly increasing its outlays for plant and equipment, but not at an unprecedented rate. Expenditures increased from $34.4 billion to $39.2 billion [15] between 1961 and 1963, a rise of 14 percent, after a period of decline. Estimates for 1964, based on planned expenditures, show a continued rise, with the total expected to be about 28 percent higher than 1961. This expansion in capital expenditures will have lasted longer than the previous expansion from 1955 to 1957, but the percent increase will have been about the same. (These figures are based on the dollar amount and are not adjusted to take account of price changes. The "real" increase, therefore, may be smaller.)

Data from the gross national product accounts show that investment in producers' durable equipment was $31 billion in 1963,[16] higher than in all preceding years (all in 1963 dollars). However, such investment as a percent of gross national product dropped sharply in 1958 then rose somewhat, but since then has been lower than any year of the period 1946–57. The rate was 5.3 percent in 1963 compared, for example, with 6.2 in 1957.[17]

Whether today's capital expenditures differ markedly in their potentiality for increasing industrial productivity is difficult to determine. McGraw-Hill surveys report that the proportion of manufacturers' capital spending allocated to

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[12] National Science Foundation data; published in *Economic Report of the President,* op cit.

[13] *Manpower Report of the President and A Report on Manpower Requirements, Resources, Utilization, and Training* (Washington: U.S. Department of Labor, March 1964), pt. III.

[14] McGraw-Hill Department of Economics, *Business Plans for New Plant and Equipment, 1962/1965,* 15th Annual Survey (New York: McGraw-Hill Book Co., Inc., 1962).

[15] Securities and Exchange Commission; reported in *Survey of Current Business,* Vol. XLIV, No. 3 (March 1964).

[16] U.S. Department of Commerce; preliminary 1963 data published in *Economic Report of the President,* op. cit.

[17] *Economic Report of the President,* op. cit., table C–2. Estimates for 1963 are preliminary.

"automated machinery and equipment" rose from roughly 11 or 12 percent in 1955 and 12 percent in 1959 to around 18 percent in 1963. The expected ratio over the 1964–67 period is slightly higher—20 percent. (Automated machinery is defined as "the use of advanced mechanical equipment, especially in combination with self-regulating controls and/or high-speed computers in manufacturing, accounting, distribution, and all other operation.")

In short, the evidence on capital expenditures—a "governor" on the pace of technological change—shows some increase in the rate but no drastic departure from previous trends. An important, but unmeasured, factor is the extent to which new capital investment has a higher degree of laborsaving or capital-saving potential.

Implications for Productivity and Employment Trends

These changes in technology, investment, and research and development are expected in the long run to offer opportunities to improve the material well-being and to increase the leisure of the American people. However, the long-run benefits may have other implications for productivity, employment, and job displacement during the shorter run—that is, during the next few years.

Taking into account the recent and postwar trends, the technological changes occurring (or on the horizon) in many industries, expected rates of investment and expenditures for research and development—and assuming a continuation of approximately the average postwar increase in private gross national product—it seems unlikely that the trend of productivity will fall below the 3-percent rate. This is in terms of an averaging out over the next few years since there are likely to be annual fluctuations, particularly if cyclical business fluctuations should occur. Whether or not the rate will accelerate is very difficult to determine in the light of evidence currently available.

As we look back over the statistical history, we find that large increases in productivity have occurred in the past, often followed by a slackening of the rate. However, these fluctuations in productivity gains are often related to fluctuations in the rate of economic growth, that is, to the changes in private gross national product. In this context, the experience of the period 1960–63, despite its brevity, and that of other periods of high economic growth are relevant to future expectations. If private gross national product should continue to rise at the rate it achieved in the past few years, over 4 percent annually, it is not unlikely that productivity would also maintain its recent higher than 3-percent rate of increase per year and, therefore, result in a restraint on the rate of employment expansion. This can also be looked at the other way around—if the productivity gains are high, it is not unlikely that output would also rise at a high rate, in which case employment would not decline.

This paper has dealt largely with aggregative analysis of productivity trends and their relationship to output and employment. Obviously, not all of the dimensions of employment-unemployment problems have been explored. For example, output must rise faster than productivity in order to provide job opportunities for new entrants to the labor force. An additional increment to output is needed to reduce the current rate of unemployment. However, the analysis has shown that, generally, as the rate of gain in output rises, so does that for productivity, even though not to the same degree, so the process of whittling down the unemployment rate is a very difficult one.

The analysis of trends among individual industries has also demonstrated that relationships at large aggregate levels, such as the total private economy, may obscure the structural types of changes that are taking place within the economy. Even in times of expansion, many plants and industries are undergoing technological or other changes which result in employment losses. The decline in employment opportunities in such plants or industries may result in serious unemployment problems for particular groups of workers—such as inexperienced teenagers, older workers, and members of minority groups—who are not adequately prepared for entry to the new jobs which may arise in other occupations, industries, or localities. Thus, technological progress tends to bring with it continuing problems of technological displacement of workers and continuing programs are required to assist workers in locating new and remunerative employment.

THE PACE OF TECHNOLOGICAL CHANGE AND THE FACTORS AFFECTING IT

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THE ACHIEVEMENT OF RAPID technological progress and its potential benefits in terms of economic growth and higher levels of living, without undue hardships for individuals, is a goal that transcends national boundaries. This conference and its agenda bear witness to the priorities assigned to this objective on both sides of the Atlantic Ocean.

In this paper, I shall be concerned with the current directions of technological change, the evidence as to the pace of such change, and the factors which speed and impede it. In conclusion, the probable manpower impact of current technological developments and their implications for manpower policy will be considered briefly.

TECHNOLOGICAL CHANGE AND AUTOMATION

In assessing the manpower implications of technological change, it is important to look broadly at the full range of developments now under way, not merely at those appropriately categorized as "automation." One of the most notable characteristics of present-day technology is the great number and variety of innovations already introduced or under development. Many of these innovations are of minor significance in themselves, but in combination with a major development they can have a large impact. Thus, the many devices auxiliary to the computer have greatly extended its economic, organizational, and manpower effects. Furthermore, there are many innovations of far-reaching importance in themselves which do not represent automation—for example, the diesel locomotive, atomic power, and the oxygen process of steelmaking.

The definition and classification of technological innovations are matters of complexity and difficulty, because of the variety and lack of standardization of these innovations and the endless variations in their applications. This difficulty of definition is so great as to constitute a major barrier to direct statistical measurement of the extent of technological change. Nevertheless, it is appropriate to indicate the general sense in which the terms "technological change" and "automation" are used in this paper.

Note: Miss Helen Wood, Special Assistant to the Director of the Office of Manpower, Automation and Training, who has been responsible for the innovating program of contractual research in the field drawn upon in part in this paper, directed the research for the paper and otherwise cooperated in its preparation.

Ed Note: At the time this paper was presented, Dr. Wolfbein was serving as Director, Office of Manpower, Automation and Training.

Technological change is here considered to include all innovations which result from the application of scientific and engineering knowledge and techniques to the processes of production and distribution and other economic operations. The purpose of such change may be either new or improved goods or services or greater efficiency of operations, usually aimed at cost savings.

What segment of technological change should be regarded as automation? This is a question to which experts give widely different answers. One authority goes so far as to say that "automatic manufacturing and even the automatic machine are only relative states, which are constantly in evolution," and to recommend that automation be used to mean simply "a significant advance in automaticity." [1]

This relativistic approach is a highly realistic one from a technological point of view, but it does not meet the needs of economic and statistical analysis. For such purposes, the admittedly loose definition used in this paper seems preferable—namely that automation embraces machines which carry through a series of operational steps without human intervention, and those at the more advanced stage of technology where mechanisms replace human labor in monitoring and frequently in controlling work, as well as in performing it.

Areas of Advancing Technology

There are 11 broad areas of technological change of surpassing importance in the United States and other nations. The far-reaching innovations in progress in these areas are together transforming, to an ever greater extent, our manner of living and the shape of the world of work.[2]

First and foremost in terms of their economic and employment effects are the technological changes in *agriculture*. These include new and improved farm machinery and the greatly increased use of such machinery, new fertilizers and insecticides, new crops and strains of livestock, and, in general, greater knowledge of and attention to scientific methods of farming. Because of these many kinds of changes and also of the trend toward larger farms, only two-thirds as many workers are now employed in agriculture as a hundred years ago, and yet this country's farms are producing enough food, feed, and fiber for a population which has multiplied more than fourfold during the past century. Since technological advances and consequent increases in worker productivity are continuing to be rapid in agriculture, we expect a further drop in farm employment (perhaps to as little as 4 million by 1975, as compared with 4.9 million in 1963).

Outside of agriculture, the innovation which is probably of greatest economic and social significance, at least potentially, is the *electronic computer*. Work on the development of the first such computer, the ENIAC, began little more than two decades ago. The idea for this project and its initiation in 1943, with support from the Army Ordnance Corps, were the direct result of the desperate need for a more efficient machine to help in computing artillery firing tables. It has been stated that "there was nothing in the completed ENIAC that could not have been put together at least a decade before the war, if anyone had had the incentive to do it." [3]

Use of computers in the civilian economy did not begin until 1951, when the first UNIVAC was applied to processing of data from the census of population. But it is estimated that by June 1964, there were close to 20,000 general-purpose digital computers in use and nearly 10,000 more on order.[4] Smaller numbers of special-purpose computers were also in use and on order. Computers are now being applied to hundreds of different kinds of uses, ranging from simple processing of business data to the most complex scientific computations. Furthermore, the number and variety of applications are being extended constantly, as a result in part of the development of new models of computers and new auxiliary equipment but also because of growing understanding of the types of uses to which electronic data processing (EDP) can be effectively applied. It would appear that, in the present generation of computers, invention has become the mother of necessity, as well as vice versa!

Instrumentation and automatic controls represent another rapidly growing and developing area of technology, which is contributing directly to automation as well as to other forms of technological progress in many industries.

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[1] James R. Bright, *Automation and Management* (Boston: Harvard University, 1958), pp. 54 and 55.

[2] For further discussion of these categories of developments, see *Manpower Report of the President and A Report on Manpower Requirements, Resources, Utilization, and Training* (Washington: U.S. Department of Labor, March 1963), pp. 73–74, and (March 1964), pp. 52–61.

[3] Jeremy Bernstein, *The Analytical Engine* (New York: Random House, 1964), pp. 55 and 56.

[4] See *Computers and Automation*, Vol. XIII, No. 7 (July 1964), pp. 52 and 53.

A particularly advanced type of automation results when computers are applied to process control in industries such as chemicals and electric power. In plants with control systems of this kind, complex computations based on vast quantities of operational data supplied by instruments can be made rapidly and accurately and the results fed back to guide the control instruments. While this type of automation is still in an early stage of development, it has had considerable recent growth.

Numerical control of machine tools and certain other types of metalworking equipment is still another important new development, which is being used to achieve more automatic production. It was first used commercially in 1957. By early 1963, about 3,000 numerically controlled machine tools had been installed, but these still represented only a tiny proportion of the total of about 2 million machine tools then in place. The use of numerically controlled devices is being rapidly extended, however, not only in machine shop operations but also in a variety of other areas.

Numerically controlled devices have the great advantage of flexibility and applicability to small orders, whereas earlier types of automation in metalworking industries were designed for mass production. Numerical control thus has the effect of greatly extending the areas of metalworking which can be automated.

Advances in communication technology range from more automatic telephone operations to improvements in television and the communications satellite. Of special significance from the viewpoint of automation is data transmission by telephone lines or other channels. This is expected to become an important adjunct to data processing activities in many industries, facilitating rapid distribution and utilization of data and centralized control of operations.

Improvements in machinery also continue to be an important aspect of technological change in many industries.

A direction in machinery design which is contributing to automation is the trend toward integration of a number of hitherto separate steps into one large machine which can carry through the series of operations with little if any human intervention. Thus, many automatic transfer lines have been built which integrate materials-handling equipment with a series of machine tools or other devices.

Tasks still done largely by hand are also being mechanized increasingly. To cite a few examples, harvesting of fruit and vegetable crops may be revolutionized by the development and wider adoption of specialized machinery. And machines for assembly work, one of the factory operations most difficult to mechanize, are being introduced by large companies in a number of industries.

The *mechanization of materials handling* is also advancing in manufacturing, transportation, and other industries. Among the innovations which are being introduced are more powerful and efficient forklift trucks, hoists, cranes, tractors, and conveyors, including pneumatic conveyors for moving granular materials by air pressure. Through the combination of electronic devices with unmanned trucks or conveyors, warehousing operations are being mechanized—and in some cases highly automated—in large retail and wholesale companies, airfreight terminals, and other types of business organizations.

Another category of technological change of basic importance in our economy, which operates largely on and by means of metals, is *new developments in metal processing*. These include the basic oxygen process of steelmaking, continuous casting, and a variety of other advances which are bringing us nearer to the ultimate objective of automation of the entire iron and steelmaking process.

Technological advances in the U.S. iron and steel industry will be spurred in the near future by increased capital investment; the industry's capital spending is expected to be at least 25 percent higher in 1964 than 1963, and may rise further in 1965.[5] And the emphasis in this new investment is reported to be installation of the latest, most advanced equipment (rather than primarily on expansion in capacity, as during the first postwar years), partly because of the pressure of competition from many highly advanced and efficient foreign mills.

Technological advances in transportation of all types—by rail, air, water, highway, and pipeline—are also underway.

Higher speeds and larger sizes of vehicles are anticipated in all forms of transportation with definite laborsaving effects. Methods of traffic control and traffic handling are being modernized and, to some extent, automated. And in water transportation the need to meet foreign competition is pushing the introduction of automated ships and other cost-saving technological improvements.

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[5] See *Survey of Current Business*, Vol. XLIV, No. 6 (June 1964), pp. 4–5.

Current *technological advances in power production* are likely to have a marked impact on the growth and regional distribution of our industrial system. An important trend, greatly facilitated by the introduction of automatic control systems by electric power companies, is the trend toward regional coordination and interchange of electric power. Another major trend is toward the development of new sources of power, particularly nuclear generators. It is reported that "low-cost" nuclear generating stations, economically competitive with plants using coal as a source of power, will be in operation within the fairly near future. Some utility companies are already building nuclear generators, and the likelihood that others may do so is putting pressure on the coal mining and railroad industries to make price cuts which will reduce the cost of delivered coal.

Finally, a stream of *new products and materials* are being developed continuously, which have a profound effect on demand and thus on employment in many industries. It has been estimated that 25 percent of the total value of manufacturers' sales in 1962 was accounted for by products not produced 10 years earlier. In some industries the proportion was much higher than this (for example, 60 percent in transportation equipment and 49 percent in electrical machinery).[6] The effects of important new products in creating jobs can be seen also in the rapid growth in the production of semiconductors (where employment doubled between 1958 and 1962) and in electronics manufacturing (where employment increased by over a third during this same period).

When new products and materials take the place of older ones, the creation of new jobs may be partly offset by elimination of work on the outdated products. On balance, however, product innovation is undoubtedly a strong influence in the direction of employment growth, though also causing shifts in employment requirements and resulting displacement and readjustment problems.

INDICATIONS AS TO THE PACE OF TECHNOLOGICAL CHANGE

The range and variety of innovations currently underway and the breadth of their occupational and industrial impact are suggested by even this capsulized discussion of major trends. There are few, if any, major occupations or industries in the United States which are not being affected to some degree by technological change. Nevertheless, it appears that in some broad areas of the economy—particularly the service industries—technological developments are still having a relatively minor impact.

Before considering the indications as to the pace of technological change, I should like to emphasize that we do not have today any substantial direct evidence on this subject. This is why the pages that follow discuss a variety of indirect indications of the rate of technological progress.

It seems to me that in the field of statistics on technological change and productivity we stand now where we were in the field of labor force, employment, and unemployment statistics back in the 1930's. At that time, we were forced to use a variety of indirect evidence for assessing labor force developments. It was only by facing up to the problem boldly and engaging in a large-scale program of collection of statistical data that we were finally able to attain perception and measurement in this field. In my judgment, we will not reach the same stage in the productivity field without a comparable systematic program of periodic direct collection of data. Only by obtaining information on output, man-hours, production methods, and related factors for a sample of products and a sample of plants in a sample of industries will we really find out what is happening to rates of technological change and productivity and the factors affecting them.

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[6] McGraw-Hill Department of Economics, *Business' Plans for New Plants and Equipment, 1963–1966*, 16th Annual Survey (New York: McGraw-Hill Book Co., Inc., 1963), table XIV.

Productivity Indexes

Such being the case, what indications are there as to the pace of technological change? For the economy as a whole and some of its major sectors, the indexes of man-hour productivity compiled by the Bureau of Labor Statistics are an important source of indirect evidence. Since these indexes were discussed by Mr. Leon Greenberg in his paper, only a few trends of particular relevance to the present discussion will be mentioned here.

The average rate of productivity gain for the total private economy has been distinctly higher in the postwar period than in the previous four decades (3 percent per year in the period 1947–63 as compared with 2 percent in the period 1909–47). This difference probably reflects, in large measure, a relatively rapid postwar rate of technological change (though productivity trends are, of course, influenced also by changes in production levels and other economic and social factors).

The pickup in productivity gains during the past few years as compared with the rates achieved during the 1950's, is worth noting also. However, as Mr. Greenberg's analysis indicates, it is too soon to reach firm conclusions as to the significance of this advance. It may prove to be either a temporary gain, resulting chiefly from higher production levels, or a more long-term phenomenon brought about in part by a recent acceleration of technological progress.

The Growth of Science and R&D Programs

Another kind of evidence which has been adduced in discussions of the pace of technological change is the exponential growth of science.[7] The rapid growth rate of scientific knowledge surely offers the possibility of tremendous advances in technology, though it provides no certainty that these will be realized.

There may be long intervals between basic scientific discoveries and the inventions these make possible and between inventions and their initial and widespread application. And it goes without saying that inventions affect the economy only as they are applied.

What evidence there is as to the interval between inventions and their application suggests that this has tended to shorten in recent decades. The Bell Telephone Laboratories have compiled the following illustrations in support of this conclusion.[8]

Innovation	*Year of discovery*	*Year of application*
Electric motor	1821	1886
Vacuum tube	1882	1915
Radio broadcasting	1887	1922
X-ray tubes	1895	1913
Nuclear reactor	1932	1942
Radar	1935	1940
Atomic bomb	1938	1945
Transistor	1948	1951
Solar battery	1953	1955
Stereospecific rubbers and plastics	1955	1958

An explanation of the rapidly narrowing interval between scientific discovery and application illustrated by figures is not hard to find. It centers in the enormous increase in the human and financial resources devoted to developing products and processes.

Merely during the past decade, the national expenditure for R&D work has tripled, rising from slightly over $5 billion in 1953–54 to nearly $16½ billion in 1962–63, according to estimates by the National Science Foundation.[9] The number of scientists and engineers engaged in R&D work nearly doubled during the past decade, exceeding 450,000 by early 1964.

We do not have figures on how the increases in R&D expenditures and personnel have been divided between research and development, but two statements can be made with confidence. First, the expansion in funds and scientific and engineering employment has extended to both types of activities. And, second, the amounts of money and numbers of people involved have been and are much greater in development than research. According to one estimate, it takes almost 10 times as many people to develop a product or process for use as to conduct the research involved in making a discovery.[10]

In view of the great increase in R&D work, it may seem surprising that the overall gains in productivity have not been more rapid and more clearly indicative of a general acceleration of technological change. One reason for this seemingly paradoxical situation is the defense orientation of a large part of the country's R&D effort. About two-thirds of the national expenditure for research and development is Government financed, and the great bulk of this Government work is connected with the defense and space programs. Government-sponsored research has, however, made important contributions to the civilian economy—not only the first computer but also radar, nuclear power, major improvements in instrumentation, and a variety of other advances in products and processes. And although civilian applications of defense and space research are likely to be delayed and limited, the hope is that they will be speeded and increased by intensified Government efforts to adapt advanced military technology to civilian uses.

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[7] See, for example, Eli Ginzberg (ed.), *Technology and Social Change* (New York: Columbia University Press, 1964), chs. 2, 4, and 6.

[8] See William O. Baker, "The Dynamism of Science and Technology," in Ginzberg, op. cit., p. 87.

[9] *Economic Report of the President* (Washington: U.S. Council of Economic Advisers, January 1964), p. 108.

[10] See William O. Baker, "The Dynamism of Science and Technology," in Ginzberg, op. cit., p. 85.

The R&D activities financed by private industry have as their direct purpose the creation of new or improved products or processes (except for the relatively small amount of industry-supported basic research). And the postwar expansion in industry-financed R&D work, though not equal to that on Government contracts, has nevertheless been very impressive—from $2.2 billion in 1953 to $4.8 billion in 1962.[11]

It would appear, on a priori grounds, that this great and persistent expansion in private industry's own R&D activities must be paying dividends in terms of an increasing flow of technological innovations. And statistical evidence for a few industries supports this general conclusion, though with some reservations.

According to a study of the chemical, petroleum and steel industries, the number of important inventions carried out by a firm is highly correlated with the amount of its R&D expenditures (as well as with certain other factors, notably the size of the firm).[12] Although the payoff from any one R&D project is obviously uncertain, there is, as would be expected, a close relationship over the long run betwen the amount a firm spends on R&D and the total number of important inventions produced.

Furthermore, the rate of occurrence of innovations in these industries has tended to increase over time, though not as fast as R&D expenditures.[13] This comparison suggests that the financial investment required to produce an important innovation has risen considerably. As pointed out in the report, if this finding holds true for most other industries, the great increase in R&D expenditures may substantially overstate the rise in the rate of innovation.

The emphasis on creation of new products rather than new processes in much of private industry's R&D work also greatly influences the contribution research and development makes to advances in productivity, as well as the ultimate effect on employment. About seven out of every eight of the companies reporting in a 1962 survey by the McGraw-Hill Book Co. planned to concentrate their R&D money on new-product research or product improvement. Only one out of eight was expecting to emphasize chiefly new-process research.

From the viewpoint of overall trends in employment, this is an encouraging finding. As indicated earlier, the net effect of product innovation is certainly in the direction of job creation. But it must be recognized that product as well as process innovation can lead to serious displacement and readjustment problems for many workers, because of shifts in employment requirements among industries and occupations as one product takes the place of another.

Rate of Diffusion of Technological Developments

The pace and extent of technological change are the outcome not merely of the flow of innovations from R&D laboratories but also of the rate at which new developments are diffused through industry. Once an innovation has been introduced by a firm, how long does it take other firms to follow suit? And what factors determine the speed of this diffusion process?

One of the few studies to provide data on these questions was part of the same series (conducted by Edwin Mansfield for the National Science

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[11] Research and Development in American Industry, 1962," *Reviews of Data on Research and Development*, No. 40 (Washington: National Science Foundation, September 1963), p. 8.

[12] This was one of a series of studies conducted for the National Science Foundation by Edwin Mansfield. See "Inquiries Into Industrial Research and Development," *Reviews of Data on Research and Development*, No. 38 (Washington: National Science Foundation, March 1963), p. 4.

[13] The tendency for the rate of occurrence of innovations to increase over time was sufficient for it to be listed as one of the principal conclusions of the study. This tendency was, nevertheless, categorized as statistically nonsignificant. In the study any observed tendency or effect was so classified when the probability was greater than 1 in 20 that it might be due to chance.

Foundation) as the study of the relation of R&D work to innovation cited earlier. The analysis of diffusion rates covered 12 important innovations in 4 major industries: The shuttle car, trackless mobile loader, and continuous mining machine—in the bituminous coal industry; the byproduct coke oven, continuous widestrip mill, and continuous annealing—in the iron and steel industry; the pallet-loading machine, tin container, and high-speed bottle filler—in the brewing industry; and the diesel locomotive, centralized traffic control, and car retarders—in the railroad industry.[14]

All these innovations (except the tin container) are heavy equipment, the use of which (with one further exception) has resulted in substantial reductions in production costs.[15] The earliest innovation of the 12, the byproduct coke oven, was introduced before 1900; the most recent, the high-speed bottle filler, well after the end of World War II.

That the diffusion of a new technique has been a fairly slow process is one of the major findings of the study. After the first commercial application, it took 20 years or more for all the major firms in the relevant industries to install centralized traffic control, car retarders, byproduct coke ovens, and the continuous annealing process. This happened within 10 years in only three instances—the pallet-loading machine, the tin container, and the continuous mining machine.

Other marked differences in the rates of diffusion were noted. For example, almost 15 years elapsed before half the major pig iron producers had adopted the byproduct coke oven, whereas half the major coal producers were using the continuous mining machine within 3 years of its introduction into the industry. In general, it was found, as would be expected, that the rate of diffusion tended to be relatively rapid for the most profitable innovations and those not requiring large investments, and also in the more competitive industries.

Another finding, which has obvious implications for the extension of automation and other recent innovations, is that the rate of diffusion of an innovation definitely tends to speed up as its use widens. With greater knowledge of an innovation, the risk involved in installing it diminishes. Furthermore, competitive pressures rise, and what the report describes as "bandwagon effects" occur. Thus, the fact that many of a firm's competitors have adopted an innovation may lead the firm to give serious consideration to adopting it too, even if its profitability cannot be fully evaluated.

Some tendency for the rate of diffusion of new developments to become more rapid over time was noted also, insofar as this could be judged from the 12 innovations and 4 industries studied.[16] This finding parallels that cited earlier with respect to the rising rate of occurrence of innovations in the chemicals, petroleum, and steel industries. Factors mentioned as presumably contributing to an increasingly rapid rate of diffusion of technological change are the improvement in channels of communication with respect to new developments, more sophisticated methods for determining the time at which equipment should be replaced, and possibly more favorable attitudes toward technological change.

Industry Differences in the Pace of Technological Change

The wide differences among industries in the pace of technological change suggested by these findings on diffusion rates are confirmed—or, it might be more accurate to say, further illustrated—by the other evidence available.[17] To cite just a few examples:

Agriculture has far outdistanced the nonagricultural economy in productivity gains over the postwar period, because of the many kinds of technological changes mentioned above. From 1947 to 1963, the annual increase in farm output per man-hour averaged 5.7 percent, compared with an average productivity gain of only 2.4 percent per year in the rest of the private economy.

The *automobile industry* pioneered during the late 1950's in the installation of automatic assembly lines, involving integration of automatic transfer devices with processing machinery. It is also continuing to introduce a variety of other laborsaving innovations. In consequence, the estimated 1964 output of 7.8 million automobiles was produced with about one-sixth fewer workers than were required for the very similar 7.9 million car output of 1955.

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[14] See "Diffusion of Technological Change," *Reviews of Data on Research and Development,* No. 31 (Washington: National Science Foundation, October 1961).

[15] It was found that continuous annealing was often no cheaper than previous processes, but was necessary to meet customer requirements.

[16] This tendency, like the finding with respect to the rising rate of occurrence of innovations, did not meet the test of statistical significance used in the study. See footnote 14, this page.

[17] For descriptions of current technological trends in major industries and a summarization of related statistics, see *Technological Trends in 36 Major American Industries,* Prepared for the President's Committee on Labor-Management Policy (Washington: U.S. Department of Labor, Bureau of Labor Statistics, 1964).

Petroleum refining has been characterized by a trend toward fewer, larger and more fully automated refineries. In this industry, output per man-hour rose at an average annual rate of 6.6 percent from 1957 to 1960 (the last year for which figures are available), well above the rate of 5 percent achieved from 1947 to 1957. Though the industry's total output has risen fairly steadily, the expansion has not been great enough to offset the productivity gains and prevent a drop in employment (amounting to 19 percent between 1957 and 1963).

In the *railroad industry*, where major technological changes have been introduced in all departments, productivity gains have accelerated—from an average rate of 3.7 percent per year in the period 1947–57 to 5.6 percent in the period 1957–61. The rise in output per man-hour, combined with the decline in railroad traffic, led to a 31 percent drop in railroad employment between 1957 and 1963.

In *banking*, the introduction of electronic data processing began in the mid-1950's and is now proceeding rapidly, especially in the processing of demand deposits. However, the volume of banking business is also growing rapidly and bank employment is therefore continuing to increase substantially, though by no means as fast as would have been required to handle the same amount of business without automation.

In *retail trade*, employment continues to rise steadily (by 9 percent between 1957 and 1963) because of the increasing volume of sales. Technological developments in process of diffusion in the industry include machine vending and other self-service techniques, EDP in accounting and control operations, and more advanced materials-handling equipment in warehouse operations. However, the extent and overall employment effect of technological change apparently continue to be much less in trade than many other industries.

Generalizations as to the industrial pattern of technological change are hazardous at the present stage of knowledge and experience. But there are a few which are well supported and of considerable significance from an economic and manpower viewpoint.

Technological change clearly has tended to be less rapid and to have less effect on productivity and employment in most service industries (including trade) than in goods-producing industries and others of basically mechanical nature. The shift in employment toward service-producing industries in recent years is accounted for partly by this fact, though also by the fact that these industries have recently been the ones which have had the most rapid gains in output (as measured by real gross product).[18]

The existence of wide variations among industries in the rate of advance in technology and productivity is in itself a generalization of major significance from a manpower viewpoint. The overall statistics on productivity trends perforce average out these industry differences. In consequence, these statistics provide only a partial indication of the magnitude of the problems of worker readjustment created by automation and other rapid technological advances in many industries.

MANAGEMENT DECISIONS TO AUTOMATE

Technological innovations are introduced initially and diffused through industry as a result of management decisions, which depend, in turn, on many economic, institutional, and technical factors. The nature of some of these factors has already been suggested at several points in this paper. But added insights with regard to them and their technological and manpower implications are provided by a recent study conducted for the Department of Labor by Stanford Research Institute (SRI).[19]

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[18] See *Manpower Report of the President*, 1964, op. cit., p. 50.

[19] *Management Decisions to Automate*, prepared for the Office of Manpower, Automation and Training, Manpower Administration, U.S. Department of Labor, by Stanford Research Institute, 1964. (Unpublished report available in depository libraries; a monograph may be obtained from the Office of Manpower, Automation and Training.)

The project involved eight case studies of management decisions regarding automation—two relating to the installation of electronic data processing systems in banks, two to the installation of numerically controlled machines (a machine tool and a wiring machine) in electronics manufacturing firms, and three to the installation of automatic order-picking and conveyor systems in warehouses. The eighth case study was concerned with a decision *not* to install a proposed automatic order-picking system in a warehouse and the cost and other factors which led to this negative outcome.

The study plowed new paths. In the process, it has increased our understanding in four important areas (insofar as judgments can be reached on the basis of case studies, supplemented by a broad knowledge of industrial trends). These areas are (1) the factors influencing decisions to automate; (2) how the results of automation have compared with management's expectations; (3) the implications with respect to the spread of automation, and (4) the probable manpower effects. Following are some major findings of the study, together with a few related findings from earlier studies.

Factors Considered and Relation of Results to Expectations

Cost reduction at the time of automation appears to be the major objective when decisions are made to automate. And it is primarily through the effect of automation on labor productivity that cost reduction is sought. In all but two of the eight cases included in the SRI study, immediate cost reduction resulting from increased productivity was the determining factor. This was true where automation was decided against, as well as where it was approved. In general, it was this effect of automation that received the most attention from decisionmakers.

In five of the eight cases studied, management calculated the amount of time it would take savings resulting from the change of systems to offset the capital investment involved in the automatic system. Favorable decisions were made in four of these cases—on investments expected to pay for themselves through lower costs in periods ranging from less than 1 to less than 5 years. While not all companies reduced costs at the time of change as much as their preautomation studies indicated would be possible, this has not caused management dissatisfaction. Savings have increased over time as business has expanded, and the actual payback periods in the four cases for which data are available were between just over 1 year and approximately 4 years.

The desire for cost stabilization was an aspect of cost reduction which had a considerable influence in several cases. Through automation, labor and other direct costs are greatly diminished relative to fixed costs, thus decreasing the effect on total costs of changes in volume of production. This was a primary reason for changing to EDP at "Suburbia National Bank," was very important in one of the warehouse cases, and was mentioned as a factor in the other cases.

Since an expansion in business was anticipated (and subsequently realized) by all the companies, they purposely acquired equipment which would not be worked to full capacity by the volume of business at the time of installation. This meant that at least some growth could be absorbed without additional capital investment, as well as with much smaller increases in the labor force than would otherwise have been required. In addition, because labor costs would constitute a smaller part of total costs, the persistently rising wage and fringe benefit rates anticipated by management would have less effect on operating costs.

Special factors gave impetus to the desire for cost stabilization in several cases. In the banks, these related to the mounting volume of paperwork involved in their expanding businesses and the difficulty and expense involved in recruiting, training, and maintaining the required clerical work force. At "Suburbia National Bank," management reported that its main reason for interest in EDP was a vision of a "flood of uncontrolled paper" as matters were developing. At "Statewide Bank," the principal reason for interest in EDP was that it was expected to reduce or eliminate the problems inherent in a very high (75 percent or more) rate of turnover among bookkeepers. This turnover made it difficult to complete daily accounting work on schedule, caused long hours of overtime for such work, necessitated costly recruitment and training efforts, and resulted in accounting errors.

At the "Marlin Distributing Co."—a small firm which is a wholesale distributor of consumer products—brief upsurges in business at least three times a year formerly necessitated the hiring of many temporary workers in the warehouse. Often the work force had to be increased 300 percent or more. Customer service suffered greatly during such periods, pilferage and other problems multiplied, and costs rose disproportionately, owing partly to unsatisfactory temporary workers.

Following an extreme experience of this sort in the mid-1950's, the firm's owner-manager decided that there must be "a better way" to run a warehouse. He himself worked for some time on a rough design for a mechanical order-assembly system that would move goods from storage, according to invoice requirements, and transport them to the truck dock without intermediate manual handling. It took him more than a year to find a conveyor-equipment manufacturer who would undertake the project, but less than a year after that for the automatic order-assembly system to become operational. The company estimates that the system paid for itself in laborsavings within 4 years, largely through a major reduction in overtime and in the need for temporary help in peak periods.

According to all the companies studied, automation was expected not merely to reduce direct costs but also to improve product quality, accuracy of work, and customer service. There was evidence in most cases that the "image" of the company as a progressive firm was considered also. But benefits of this nature did not offset the unfavorable cost situation in the case in which an automation proposal was turned down, and they were clearly marginal, relative to the cost factors, in the other cases.

These findings correspond closely, though not exactly, with those from a study of 13 automation situations conducted by James Bright in the mid-1950's.[20] One of the major conclusions of this earlier study was that the chief impetus to automation in most of the 13 cases was a need for greater production capacity. At the same time, it was recognized that reduction in labor cost was "a prime objective in many, perhaps most, automation programs."[21] Thus, the difference at this point between the findings of the two studies is essentially one of emphasis.

Points on which there was close correspondence in findings were the general expectation of automating firms that automation would result in higher quality of output as well as in cost reduction; also that a substantially greater capital investment was normally required for the more advanced equipment and was expected to be offset, in the main, by reduced labor costs.[22]

Implications as to Spread of Automation

All three forms of automation covered in the SRI study—EDP, numerical control, and automatic order-filling systems—appear likely to spread with increasing speed in the near future, both in the industries represented in the study and in others. This was SRI's conclusion, based on the findings of the case studies interpreted against a broad background of knowledge of economic and industrial trends.

The pace at which EDP is being adopted is already quite rapid (as indicated by statistics presented earlier in this paper). In banking, EDP helps to solve major industrywide problems (the mounting volume of paperwork and difficulties with respect to clerical employees which plagued the banks in this study). It is not surprising, therefore, that virtually all of the largest banks and many medium-sized ones are either already using EDP or expecting to have systems in operation by 1965 (according to a Federal Reserve survey made in 1962). Furthermore, many banks, presumably smaller ones, are obtaining computer services through cooperative arrangements or from EDP service bureaus (according to a 1963 poll of member banks by the American Bankers Association). The use of EDP is being extended rapidly also in government and in many other branches of private industry.

In recent years, the rate of acceptance of numerical control systems, particularly in machine tools, has also begun to accelerate in a variety of industries. A factor which should help to speed this process is the trend toward reduction in the cost of numerically controlled machine tools. Twenty-five percent more machine tools of this type were sold in the first half of 1962 than in all of 1960, at a cost 20 percent less than that of all of those sold in the earlier year. The type of multipurpose machine tool purchased by one of the electronics companies studied is now available in a smaller, much less expensive model, aimed at a wider market.

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[20] Bright, op. cit., especially pp. 59–89.

[21] Ibid., p. 83.

[22] Two exceptions were found in the earlier study by James Bright: (1) A small oil refinery, which achieved a 30-percent saving in investment, as well as a 50-percent reduction in operating manpower, by building a highly integrated refinery employing an advanced system of centralized automatic control instead of a more conventional plant; and (2) a large auto parts manufacturer, whose automated conveyor system was installed for the purpose chiefly of improved inventory control and better working conditions. Bright, op. cit., pp. 69 and 72.

The spread of automatic order-picking systems, on the other hand, is still rather slow among potential users. But SRI considers it likely that such systems will spread at an increased pace in the next few years. Currently, the acceptance of new forms of automation tends to be slow and piecemeal until a significant number of firms, or several particularly important firms, have successfully adopted them. As this happens, competitive pressures build up (or appear to do so), financial and technical risks are reduced, and the pace of acceptance accelerates. In SRI's judgment, this kind of development can be expected in the near future in the case of automatic order-assembly systems in warehouses.

During recent years there has been a considerable increase in the amount of information on automation to which management is exposed. The number of trade journals, articles, and conferences devoted to various aspects of the subject has grown constantly and rapidly, leading to wider dissemination of automation ideas and of reports on the effects of different kinds of automation. Another result may be the fostering of attitudes favorable to change in the form of automation. It has been suggested that automation is becoming "the thing to do."

The similarities between this situation and the findings with regard to the diffusion of earlier innovations in the study by Edwin Mansfield referred to above are very apparent. It would appear that many types of automation may be entering the stage of "bandwagon effects" described by Mansfield, when a definite speedup in the rate of diffusion of an innovation takes place.

On the negative side, it has been argued that the amount of capital outlay required for automation may limit its extension. The relatively large investment normally demanded by automation compared to that involved in alternative systems is certainly considered by all companies. However, the SRI study suggests that the size of the capital outlays required for automation does not necessarily deter fairly small firms from installing equipment of this type (and the earlier study by James Bright also supports this conclusion). To such firms, the investments called for by automation may be large relative to total firm assets or sales, but the savings that can be expected from automation also tend to be large relative to total operating costs. Furthermore, as already noted, numerically controlled machine tools have a flexibility which makes them well adapted to use in relatively small companies. And EDP is being brought within the reach of many small organizations through the development of service centers and other arrangements for the sharing of a computer system by several organizations.

The shift from variable to fixed costs involved in automation was considered by SRI to be another factor which could limit (though, paradoxically, also contribute to) its extension. To firms with expanding businesses, such as those in the SRI study, this shift in cost structure and the consequent stabilization of operating expenses can be an important element in the expected cost reduction, upon which hinges the decision to automate. But if there is any likelihood of cuts in production the increase in fixed costs can constitute a potentially serious problem.

We postulate that when firms are doubtful as to the prospects for business growth they are unlikely to automate—except in cases where they regard a drastic improvement in operating efficiency and consequent major cost savings as a condition of survival. Thus, during the 1958 recession, when companies revised their forecasts of anticipated growth, there was a substantial drop in new orders for electronic computers and a postponement of many deliveries which had already been scheduled.

Manpower Effects

What effects did automation have on employment in the companies in the SRI study? And what do they suggest about the manpower effects of an extension of automation?

In all these cases, it will be recalled, the primary aim of automation was reduction in labor costs. And substantial cuts were actually achieved fairly soon after installation of the new equipment, not only in labor requirements per unit of output but also in the total number of workers employed in the operations directly affected. Total company employment continued to rise in several cases, however, owing to growth in business and consequent staff increases in other departments. This was true of both banks studied, whose experience in this respect parallels that of the banking industry as a whole.[23]

Another important point illustrated by the study is that automation can lead to much sharper cuts in labor requirements in a very short time than normally result from other types of laborsaving advances. This is suggested most clearly by a comparison of the experience in two of the cases studied—two warehouses belonging to the same company, of which one installed an automatic system and the other decided (following a cost analysis) that, in its particular situation, sufficient savings could be accomplished without automation by various improvements in organization and operating methods. Where the automatic system was installed, 14 people (close to three-fifths of the warehouse work force) were displaced from one week to the next. In the other warehouse, the advances in productivity achieved by other means led to the displacement of three workers (not quite one-fourth of the total number) over 5½ years.

Perhaps more important still is the fact already mentioned that automatic systems frequently are not worked to full capacity at the time of installation, and that output can therefore be increased with relatively little growth in the firm's work force. At the "Hamilton Electronics Co.," for example, the introduction of 2 automatic wiring machines, between them employing 3 men, displaced 14 wiring employees. Two years later, output had increased and the same 3 men and 2 machines were doing work that would have required about 35 people wiring by hand.

On the other hand, automation can be accomplished in many cases without actual layoffs. All the companies in the SRI study avoided layoffs altogether. And a good many other companies are known to have achieved the same record when installing automated equipment, though layoffs have sometimes been heavy.

Because of the relatively high cost of automation, it is likely to be installed one operation at a time in most cases. And when the labor displaced in a single automated operation does not represent a large proportion of the plant work force, the displaced workers can often be absorbed elsewhere in the organization. The companies studied by SRI all arranged for such transfers of workers when necessary to prevent layoffs, though they also relied on normal attrition as a means of reducing their employment.

The experience of these companies also indicates the feasibility of internally recruiting and training workers for many, if not most, automation jobs. For every different kind of job connected with the new equipment and for most of the positions in each job category, the companies recruited people from their existing work forces. Through inplant training programs or training at the plants of the equipment manufacturers, workers were prepared for jobs ranging from automatic equipment operator and maintenance technician to systems analyst and programer for a computer or a numerical control system. This was accomplished within a few weeks at most and at costs which were acceptable to management.

SOME IMPLICATIONS

Anyone who ventures a look ahead at the probable advance and economic impact of science and technology would do well to look first at a prediction made late in the last century by the then U.S. Commissioner of Labor. In an official report, he stated that the era of rapid industrial advance had ended for the civilized world—that the future of the great industrial countries held no such opportunities as had the preceding 50 years for the creation of new tools and the profitable employment of the vast amounts of existing capital. Some new processes of manufacture could be expected, he said, and these would act as an ameliorating influence, but the main task remaining was that of consolidating and utilizing the great technical discoveries of the 19th century! [24]

This dire example of underestimation of scientific and technological potentialities suggests the extreme hazards involved in any attempt at long-range assessment of the technological future. The difficulties and uncertainties should be greatly reduced when one is concerned merely with a short-range appraisal of the probable rate of diffusion and manpower impact of developments already in being or on the drawing board. Even in this arena, however, conclusions are necessarily limited and tentative, in view of the indirect and fragmentary nature of the available evidence.

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[23] See Rose Wiener, "Changing Manpower Requirements in Banking," *Monthly Labor Review*, Vol. LXXXV, No. 9 (September 1962), pp. 989–995.

[24] See *First Annual Report of the Commissioner of Labor* 1886, p. 257.

One conclusion which is supported by many strands of evidence is that technological change is not only proceeding rapidly in many industries but accelerating in at least a few. (Quite possibly, the rate of technological change has been and is accelerating in a sizable number of industries, but indications to this effect are not conclusive.) Furthermore, it appears that the rate of diffusion of various types of automated equipment, and also of some other laborsaving advances, is tending to speed up and will probably continue to do so in the near future.

This by no means implies that all of industry will shortly be automated. The evidence cited earlier shows that it normally takes a good many years before an innovation is adopted by most potential users, even though the process is likely to accelerate at a certain point. And there are large sectors of the economy, especially in the service industries, which appear relatively immune to automation and other laborsaving innovations (although even there, automatic elevators and other self-service devices are making inroads and tending to reduce employment in unskilled jobs).

As indicated in Mr. Greenberg's paper, we do not yet know what the net effect of these different trends will be on the average rate of advance in technology and productivity in the total private economy. In view of the many frequently offsetting factors, economic as well as technological, which affect the movement of the overall index of man-hour productivity, it is quite possible for this index to rise only moderately even though technology is advancing rapidly in major sectors of the economy.

But regardless of the overall trend of productivity, the fact of rapid technological advance in many industries confronts the country with manpower problems of major dimensions. It is to be hoped that actual layoffs owing to technological changes will be avoided or held to a minimum. But a great deal of "silent firing"—not filling vacancies created by attrition and not hiring additional workers as production expands—appears inevitable in the many plants installing automated or other advanced equipment of a laborsaving nature. Furthermore, great numbers of workers will have to prepare for and make occupational shifts, either within the same company or, if they have been laid off, in order to qualify for a job with another employer.

The prospect of much silent firing, probably coupled with some layoffs, obviously poses a threat of mounting unemployment for our rapidly growing labor force. Whether this develops will, of course, depend on our national rate of economic growth. Efforts to stimulate this growth—by private business and, if necessary, Government action—thus have top priority among the measures required to accomplish an effective adjustment to automation.

In addition, progress must be made in three other general directions. First and probably of most immediate urgency is the need to hold actual layoffs in connection with technological changeovers to a minimum, to provide retraining for displaced workers, and to otherwise ease and facilitate worker adjustments. It is most appropriate that the private and governmental measures which have been and can be utilized for this purpose will be the subject of discussion at a later session.

Effective preparation of young people for the changing economic and technological world they will participate in as workers is a second essential. The needs in this area will, I am sure, be considered in the discussion of the implications of automation for education and training scheduled for a later session.

Finally, we must intensify and embolden our efforts to achieve better information on the rate and employment impact of technological change, both current and prospective, and fuller understanding of the measures needed to insure a realization of its potential benefits.

Our new National Commission on Technology, Automation, and Economic Progress will be the center of deliberations and factfinding activities in this area during the coming year. Its findings and report will, I am confident, enable us all to move to a higher level of effectiveness in our continuing research and action programs with respect to technological change, productivity, and associated problems.

The active manpower policy enunciated by the President early in 1964 can also contribute essentially to an effective national adjustment to technological as well as economic change.[25] As we make progress in the three basic aspects of this policy—developing abilities, creating jobs, and matching people and jobs—we will build the strong and flexible work force and the effective job market which will enable us to realize fully the economic and social benefits potentially inherent in automation.

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[25] See *Manpower Report of the President*, 1964, op. cit., pp. XIII–XVI.

EFFECTS OF TECHNOLOGICAL CHANGE ON OCCUPATIONAL EMPLOYMENT PATTERNS IN THE UNITED STATES

Ewan Clague

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In appraising the impact of technological change upon occupational patterns in the American economy, it is necessary to define precisely what I mean by "technological change." In the broadest sense of the term, technological change can be, and often is, used as the equivalent of the second technological revolution. When used in this way, the new technology might be considered to be directly or indirectly responsible for most of the changes occurring in jobs and occupations, since it would include changes such as those resulting from the development of new products, and the Government's decision to spend increasing amounts on research and development, defense, health, and other activities.

However, I find it more useful to distinguish between the direct and indirect effects of technology. An example of the direct impact is when capital is substituted for labor, that is, a machine displaces men in the production process. In this case, the impact of technology upon occupations is simple, direct, and immediate—some jobs and occupations are eliminated, new jobs and occupations are created. The result is fewer man-hours of employment in that process. It is this aspect of technological change which causes labor displacement and often results in some unemployment.

Yet the effects of technology do not end with that simple operation. The results of the technological change (if it is important enough) can ripple throughout the economy in indirect, secondary, and remote consequences. Thus, the replacement of the horse and buggy by the automobile has brought about a tremendous expansion in road building throughout the country. However, in this case, it is more meaningful to ascribe the expanding jobs and occupations in road construction to the public demand for good roads. The size of the Government's work programs becomes the direct and immediate factor in determining road-building employment.

For the purposes of this paper, I am going to discuss the impact of technological change upon occupations in terms of the narrow definition, namely, the primary direct effect of new machines, materials, techniques, processes, etc., through the substitution of capital for labor. But first, I want to outline other major factors which produce changes in the occupational pattern of American industry. These factors may be more important than technology in determining the occupational composition of our labor force. However, some technology may be indirectly embedded in these other factors, but in any case the effect of changing technology is remote, often in both time and space. For the purpose of manpower policy and for guidance to workers in adjusting to occupational changes, it is better to treat these other factors as primary causes of occupational change.

IMPORTANT FACTORS AFFECTING OCCUPATIONAL EMPLOYMENT PATTERNS

Our studies in the Bureau of Labor Statistics demonstrate that the most important of these other factors are: (a) Growth in population and its changing age distribution; (b) Government policy—relating, for example, to the size of the defense and space programs, and to expenditures for research and development; (c) the different rates of employment growth among industries resulting from such factors as shifts in the distribution of income and changing patterns of consumption; (d) institutional factors, such as union-management relationships and practices, and (e) the relative supply of persons in different occupations and the substitution effect resulting from a shortage in one occupation and replacement by members of another—for example, technicians for engineers. Let me elaborate on the above points, with a few illustrations of each.

(a) A very large part of the increase in professional workers has been due to *population growth.* Thus, a greater number of teachers are needed to serve the rising number of school-age children; and the large increase in medical personnel is resulting from our growing population, with its changing age distribution and increasing ability and willingness to pay for medical services. The increasing urbanization of the population is further responsible for the expansion of State and local government employment in order to provide the public services needed for urban living.

(b) Our *defense and space programs,* including atomic energy and research and development, have greatly affected the occupational distribution of employment in the United States. For example, the dramatic increase in the demand for scientists, engineers, and technicians is related to expanding Government expenditures for research and development. The distinctive manpower profile—characteristic of today's defense work force, with above-average proportions of professional, technical, clerical, and draft workers and below-average proportions of semiskilled operatives—may be seen in the comparison (for 1963) of broad occupational groups in manufacturing employment as a whole and in defense-related employment in private industry (table I).

TABLE I.—*Percent Distribution of Manufacturing and Defense-Related Employment, 1963*

Occupation	All manufacturing	All defense-related employment in private industry
Total [1]	100	100
Professional and technical workers	9	15
Managers, officials, and proprietors	6	7
Clerical workers	12	15
Sales and service workers	5	6
Craftsmen	18	20
Operatives	43	31
Laborers	6	6

[1] Because of rounding, individual items do not total 100.

SOURCE: *Monthly Labor Review*, May 1964, p. 514.

Note that in the defense industry 15 percent of the work force consists of professional and technical workers, as against only 9 percent in manufacturing as a whole. In fact, throughout the whole range of the more highly skilled administrative, clerical, and craft workers, the proportions in defense industry are higher than in manufacturing. Conversely, only 37 percent of defense employment (3 workers out of 8) are operatives or laborers while about half of manufacturing employment consists of these occupations. In other words, the more that the Government spends on defense employment, the higher the quality of skills required.

Another illustration of the higher scaled structure of defense-oriented manufacturing can be seen in table II which compares the occupational distribution in plants manufacturing military and space electronic end products with that in plants manufacturing consumer products, such as radios and television sets.

In electronics manufacturing, employment in military and space products consists of 60 percent nonproduction workers and only 40 percent production workers, whereas in the manufacture of consumer products in that same industry only 30 percent are nonproduction workers and 70 percent production workers. Engineers and other technical workers were three times as numerous in military and space work, while clerical and stenographic personnel were nearly twice as numerous. Even among the production workers there was a marked difference. Nearly one-third of the production workers in military and space products plants were skilled, with the remaining two-thirds semiskilled and unskilled. On the other hand, nine-tenths of the production workers in consumer products were semiskilled and unskilled (over 63 percent of the entire work force). Of course, the major factor is that military and space products are on the frontier of technology, with emphasis on custom production with continued invention and improvement, whereas the consumer products are primarily mass-produced items with large volume.

(c) The different rates of *employment growth among industries* have been the most important single factor determining the occupational distribution of employment in the United States. A look at industry employment trends indicates that the very large increase in white-collar employment has resulted from the greater than average growth in industries employing large numbers of these workers; for example, State and local government; finance, insurance, and real estate; trade; and business and professional services; coupled with the much slower growth in industries in which smaller numbers of white-collar workers are employed—mining, manufacturing, and transportation.

Our staff in BLS have made a comprehensive analysis to determine whether the increase or decrease in employment in each major occupational group resulted primarily from (1) the varying rates of employment growth in individual industries or from (2) the changing occupational distributions within individual industries (resulting primarily from technological change). This analysis was based on occupational employment changes

TABLE II.—*Illustrative Occupational Percent Distributions in Electronics Manufacturing, Military Space, and Consumer Products, Mid-1962*

Occupation	Military and space products	Consumer products
Total employment	100.0	100.0
Nonproduction workers	60.0	30.0
Engineers and other technical workers	33.4	11.0
Engineers	21.0	6.0
Technicians	7.7	3.0
Draftsmen	4.7	2.0
Administrative and executive	13.2	12.0
Clerical and stenographic	13.4	7.0
Production workers	40.0	70.0
Skilled	12.6	6.8
Assemblers	5.2	(1)
Analyzers and troubleshooters	1.1	5.1
Processing workers	.2	(1)
Machinists and repairmen	3.7	.3
Sheet-metal workers	.8	(1)
Tool-and-die makers	.3	.4
Welders	.6	.1
Carpenters	.2	.2
Electricians	.2	.2
Plumbers and pipefitters	.2	.1
Other skilled workers	.1	.4
Semiskilled and unskilled	27.4	63.2
Assemblers	11.0	42.0
Inspectors and testers	3.1	14.4
Fabricating workers	3.7	1.2
Processing workers	3.1	1.2
Shipping and receiving workers	1.3	1.2
Material handlers, truck drivers, and laborers	.3	2.2
Custodial and janitorial workers	1.5	.4
Other semiskilled and unskilled workers	3.4	.6

[1] Data not available.

NOTE: For further information, see *Employment Outlook and Changing Occupational Structure in Electronics Manufacturing*, BLS Bulletin No. 1363 (Washington: U.S. Department of Labor, Bureau of Labor Statistics, 1963), p. 37.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics; based on information obtained through field visits to electronics establishments.

Table III.—*Change in Employment Attributable to Industry Growth and to Occupational Pattern Changes Within Industries, by Broad Occupational Group, 1950 to 1960*

Occupational group	Employment [thousands]			Employment change 1950–60 [percent]		
	Actual reported by the Census		Hypothetical 1960 employment distribution using 1950 occupational pattern of each industry	Reported by Census	Resulting from change in industry employment levels	Resulting from change in occupational patterns within industries
	1950	1960				
	A	B	C	D	E	F
Total employment[1]	55, 507	61, 465	61, 465	------	--------	----------
White-collar workers:						
Professional workers	4, 910	7, 223	7, 140	47	45	2
Managers, officials, etc.	5, 018	5, 408	5, 699	8	14	−6
Clerical workers	6, 895	9, 303	8, 622	35	25	10
Sales workers	3, 927	4, 644	4, 636	18	18	0
Blue-collar workers:						
Craftsmen	7, 783	8, 753	8, 763	12	12	0
Operatives	11, 140	11, 920	11, 971	7	7	0
Laborers	3, 431	3, 093	3, 572	−10	4	−14
Service workers:						
Private household workers	1, 408	1, 716	1, 643	22	17	5
Other service workers	4, 287	5, 456	5, 286	27	23	4
Farm workers:						
Farmers and farm managers	4, 309	2, 508	2, 643	−42	−39	−3
Farm laborers and foremen	2, 400	1, 440	1, 491	−40	−38	−2

[1] Excludes persons who did not report their occupation. Individual items may not add to totals due to rounding.

Source: U.S. Department of Commerce, Bureau of the Census, "1950 Census of Population," Vol. II, Part I, table 53, pp. 1-101; "1960 Census of Population," series PC(2), 7C table 2, pp. 7-146; and special tabulation of 1950 occupational employment by industry prepared for the Department of Labor.

which took place between 1950 and 1960, as shown by decennial census reports. Table III shows the net result of the effect of changing occupational patterns of individual industries.[1] When this net figure is deducted from the total employment changes shown by the census data, the difference represents the effect of changing employment levels of individual industries.

As shown in table III, except for laborers, the changing *employment levels* of industries had a much greater effect than shifting *occupational patterns* on the change in the number of persons employed in each occupational group. For example, among the sales, craftsmen, and operative groups no increase in employment resulted from the net effect of changing occupational patterns of individual industries. Similarly, nearly all of the 47-percent increase in employment in the professional group resulted from the changing levels of industry employment. Changing occupational patterns of individual industries apparently offset each other so that there was only a very small net increase in the employment of professional workers which could be attributed to shifting occupational structures.

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[1] The 1950 occupational distribution for each individual industry was applied to the industry employment levels for 1960. The result (column C) was then compared to the actual occupational employment level for 1960 (column B) as reported by the Census Bureau. The difference between columns B and C thus reflects the increase or decrease in occupational employment resulting from changing occupational patterns of individual industries; column F shows the percent change in the number employed. Column D shows the percent change in employment as reported by the Census Bureau. Column E, the difference between D and F, is the estimated percent change in occupational employment resulting from the increase or decrease in industry employment levels.

Note that table III and the comments on it refer only to changes in the distribution of workers among broad occupational groups *within industries.* These data conceal the vast changes that occurred *within each occupational group.* Individual occupations in the same skill group may have divergent rates of growth and adding those occupations together results in very little apparent change for the occupational group as a whole. For example, within the clerical occupational group, employment of telephone operators decreased slightly from 1950 to 1960, whereas the number of stenographers, secretaries, and typists rose by 43 percent. Similarly, within the craftsmen group, boilermakers decreased by 33 percent and air-conditioning and refrigeration mechanics increased by more than 40 percent.

(d) The occupational pattern of an industry may be greatly influenced by *collective bargaining agreements* between labor and management. The construction industry is a good example of the influence of craft unions in maintaining their occupations intact through decades of technological change. The railroad industry is another case where, in general, the influence of unions is directed toward the maintenance of occupational skills. The union influence is large enough to have some effect on the occupational patterns of the economy.

(e) *Supply and demand factors.*—Scarcities and surpluses among different occupations provide management with the opportunity to engineer the jobs to match in some degree the available labor supply. An example is the substitution of technicians for engineers under certain conditions, or the readjustment of production processes or materials so as to employ different labor skills.

DIRECT EFFECTS OF TECHNOLOGY ON OCCUPATIONAL PATTERNS OF INDUSTRIES

Now I want to turn to technology as such. Despite my observation that factors other than technology have a profound effect on the occupational structure of our labor force, I am keenly aware of the many changes resulting from technology. Technological changes have been affecting the occupational composition of our work force since man first made crude tools to lighten his work. The Congress of the United States has long been concerned with knowing more about the effects of such changes. For example, the 13th Annual Report of the Commissioner of Labor, "Hand and Machine Labor," published in 1898, states: "This report is the result of an investigation authorized by a joint resolution of the Congress, under the provisions of which the Commissioner of Labor was authorized and directed to investigate and make report upon the effect of the use of machinery upon labor and the cost of production, the relative productive power of hand and machine labor, etc. . . ."

Let me give some examples of the diverse effect technological change has on occupational structure and skill requirements. As indicated previously, a common finding of studies of industries which have been declining in employment as a result of technological developments is that the greatest decreases in employment have taken place among laborers and others in the least skilled groups. An example is the *railroad industry,* which showed very substantial alterations in occupational composition over a 13-year period under the impact of changes in technology, in the scale of operations, and in product mix. Between 1947 and 1960, the diesel engine completely supplanted the steam locomotive. There were also substantial technical improvements in maintenance of track and roadbed, and section hands who did common labor on the tracks were replaced by mobile-powered units that made repairs while moving slowly over the track. At the same time, passenger traffic declined substantially and freight traffic remained reasonably stable.

The effect of all these changes is reflected in the occupational composition of the industry. Employment dropped by more than 40 percent between 1947 and 1960 for a net loss of 571,500 jobs. However, maintenance-of-way employment dropped by 55 percent, a 69-percent decline in unskilled section hands being offset to some extent by a 47-percent increase in the number of semiskilled portable equipment operators. With the diesel-electric locomotive requiring much less repair work than the steam locomotive, skilled workers in repair shop employment dropped by 35 percent. The boilermakers were the hardest hit craft; their number declined by 82 percent. On the other hand, employment of electrical workers increased by 15 percent. Other occupational groups on the railways had smaller declines than the average for the industry. The professional, clerical, and general office employees declined by only 27 percent (affected to some extent by the introduction of electronic data processing) and the executives declined by only 1 percent. The net effect of these occupational changes was that executive and office workers increased as a proportion of total employment and unskilled workers and some maintenance crafts decreased.

The *lumber and wood products* industry is another example of an industry in which the number of unskilled jobs declined as mechanized equipment was installed. Employment dropped by more than 200,000 in the last 10 years, an average of about 2.7 percent per year. At the same time, output rose considerably, owing mainly to the use of faster and more powerful laborsaving machinery, such as high-speed handling, sawing, and sorting and stacking equipment. Wood shoppers and unskilled lumbermen decreased significantly between 1950 and 1960, while operators of portable spars, mechanical lumberjacks, and loading and other equipment increased. Technological developments are expected to have further effects. It is reported that one automatic sorting and stacking system handles between 150M and 160M board feet per shift with only two operators. An electromechanical stress-grading machine may result in more efficient utilization of lumber with possible elimination of many visual grader jobs. In addition to the decrease in unskilled jobs, here we see the emergence of new jobs—some requiring greater skill and others threatening to reduce the need for workers with skills acquired through considerable training and experience.

In *banking*, technological changes have affected occupational structure in still another way. Occupational patterns are changing rapidly as this fast-growing industry expands its use of electronic data processing equipment. The sharpest reductions in manpower requirements for a given volume of work are in the demand deposit sector where the needs for bookkeepers, proof and transit clerks, and many other routine clerical workers are being substantially reduced through the use of magnetic ink character recognition, electronic bookkeeping machines, and full-scale computer systems. Among the new jobs created are reader-sorter operator, check encoder or inscriber, control clerk, and key-punch operator. These new jobs cannot be said to require a higher skill level than those being replaced—indeed, the hand bookkeeper and even the operator of a conventional bookkeeping machine needs more training and experience than most workers in the new jobs. A few new jobs for programers and system analysts are being created at the professional and technician level. About half the people employed in banking—tellers, secretaries, typists, switchboard operators, officers, and professional workers—are not expected to be much affected by technological change and their employment will continue to rise as banks increase their facilities and add new services. (The Bureau of Labor Statistics estimates that bank employment will rise by more than 300,000 between now and 1975, despite the rapidly expanding use of electronic data processing equipment and other innovations.)

Another example of the effects of introduction of electronic computers on office employees can be seen from a study made by the Bureau of Labor Statistics of the *tax return processing* in a Southern region of the United States. This study shows that large numbers of routine and repetitive clerical jobs, particularly those relating to posting, checking, and maintaining records have been cut back substantially. Also reduced significantly were the number of operators of bookkeeping machines and other office equipment. However, it should be noted that at the same time, large numbers of key-punch operators (also classified as clerical workers) are now needed to transcribe data from tax documents to punch cards for processing by computers. Another major effect is the reduction in the number of lower-level supervisory jobs resulting from the elimination of certain routine clerical functions. Some new occupations related to administering and operating the computer system—systems analyst, programer, and console operator—were created.

Contrasts in the effects of technology are shown in the changing occupational distributions of the petroleum and baking industries. (See table IV.) In the *petroleum refining industry*, between 1950 and 1960, laborers decreased in number and proportion whereas craftsmen and professional workers increased. The increase in the employment of craftsmen resulted largely from the growing amount of maintenance needed in the highly instrumented and automated petroleum refining processes. Employment of technicians was increased because of the greater utilization of automated and computerized systems.

TABLE IV.—*Occupational Employment in the Petroleum Refining and Bakery Industries, 1950 and 1960*

	Bakeries		Petroleum refining	
	1950	1960	1950	1960
Total employed:				
In thousands	267.0	362.1	257.2	252.7
Percent distribution [1]	100.0	100.0	100.0	100.0
Professional and technical	.8	.6	14.9	16.2
Managers, officials, and proprietors	6.6	6.1	5.9	6.0
Clerical workers	8.5	8.5	17.5	18.1
Sales workers	6.7	9.9	2.1	2.2
Craftsmen and foremen	31.7	27.4	21.7	23.7
Operatives	39.5	41.5	26.3	26.3
Service workers	3.1	3.0	2.3	1.7
Laborers	3.1	2.9	9.2	5.9

[1] Base used in computing percents was the total employed less the number not reporting occupations.

SOURCE: U.S. Department of Commerce, Bureau of the Census.

In the *baking industry*, on the other hand, the biggest increases in proportion of total employment occurred among sales workers and operatives, whereas craftsmen declined as a proportion of the total. The decline in the relative importance of craftsmen is attributable to changes in technology, such as the introduction of continuous mixing units and modernized ovens in which products are baked while passing through the oven on a conveyor. In addition, because perishable items can be frozen, they are produced in much larger quantities, thus contributing to the reduction in the relative number of skilled bakery workers required. The increase in sales workers is related to the greater number of driver-salesmen required to handle the much larger volume of bakery products. The increase in proportion of semiskilled workers resulted to a great extent from the large expansion in the number of truck drivers—more than offsetting the decrease in operatives needed because of the introduction of automatic slicing, packaging, and other machines.

The change in technology in the *telephone industry* has resulted in an occupational shift different from those previously described. Table V shows that the greatest shift has been the decrease in the proportion of telephone operators and other clerical workers resulting from the conversion from manual systems to automatic dial services for local and long-distance calls, and the introduction of automatic timing and billing devices. At the same time, linemen, telephone installers, and repairmen have increased because of the growing number of telephones as well as the complexity and growing volume of telephone services.

TABLE V.—*Occupational Employment in the Telephone Industry, 1950 and 1960*

	1950	1960
Total employed:		
In thousands	594.8	692.5
Percent distribution [1]	100.0	100.0
Professional and technical	4.9	6.5
Managers, officials, and proprietors	3.7	5.4
Clerical workers	62.5	55.5
Telephone operators	(44.2)	(31.8)
Sales workers	.3	1.1
Craftsmen and foremen	24.9	28.6
Linemen and servicemen	(22.0)	(25.5)
Operatives	1.2	.7
Services workers	1.6	1.7
Laborers	.8	.5

[1] Base used in computing percents was the total employed less the number not reporting occupations.

SOURCE: U.S. Department of Commerce, Bureau of the Census.

Perhaps the most dramatic technological change of all has taken place on the farm. As a result of increased mechanization, the use of scientific methods, chemical fertilizers, better seeds and the like, productivity in *agriculture* has increased much more rapidly than in most other industries. Employment has declined despite the need to grow more food for the increasing population. Furthermore, the occupational structure of farm employment has been affected. For example, between 1950 and 1960, when farmers and farm laborers decreased by about 40 percent, the number of professional workers in agriculture rose by about 20 percent—such workers include airplane pilots (for crop dusting), scientists, foresters, accountants, veterinarians, etc.

The effect of technological change on the occupational structure of most industries is complex and cannot be traced easily. For the most part, technological innovations are not adopted extensively in an industry or an individual plant at any single time. Rather they are often adopted piecemeal in the form of a great many minor changes introduced in one establishment and then in another and often in a gradual way within an establishment. In view of the multitude of small changes having a different effect on the occupational pattern of an industry, the only way to see the net effect of all technological changes is to examine the total composition of the industry from time to time.

Unfortunately, as yet no comprehensive data on changing occupational employment patterns in individual industries are available in the United States. Except for the data available from the decennial censuses, our conclusions are based on special surveys of specific industries, studies of individual occupations, or the analysis of the effects of a particular technological development on employment. We need to know a great deal more about the shifts taking place in the occupational structure of our work force before we can measure, with confidence, the net effect of these changes. (The Bureau of Labor Statistics is now developing procedures for collecting current employment statistics by occupation so that we can keep abreast of the changing occupational needs of the Nation.)

HOW INDIVIDUAL OCCUPATIONS ARE AFFECTED BY CHANGING TECHNOLOGY

Let me now turn to the effect of changing technology on the skill requirements in individual occupations. Although it is difficult to measure changes in skill requirements, it is possible to make a few generalizations and to cite a few specific examples based on research conducted by the Bureau of Labor Statistics in the course of preparing the *Occupational Outlook Handbook*.

As our economy and technology have become more complex, the skill levels required for many occupations have increased. For example, many *business machine servicemen* need a broader technical knowledge than ever before—especially of electricity and electronics—to service the complex office machines coming into use. Many experienced *maintenance electricians* must now learn basic electronics to maintain and repair the complex new equipment being installed. More complex modern metalworking equipment is raising the technical skills required of *tool-and-die makers*, and a knowledge of mathematics, the basic sciences, electronics, and hydraulics is becoming more and more necessary to perform this work. The work of *appliance servicemen* requires greater skill than ever before, and a good working knowledge of electricity and electronics, because of the growing use of electric control devices in household appliances.

But technological change has not increased skill requirements in all occupations. There are many occupations in which technology has reduced the level of skill required. Consider what has happened to the *shoemaker*, whose all-round skill has been diffused into a proliferation of more than 50 occupations (cutter, stitcher, caser, shank fitter, heel blocker, etc.), most of which require little training or experience.

In some instances, the use of numerically controlled machine tools has reduced the skills of *machine-tool operators*. The operator no longer adjusts the speed or cutting depth of the tool because these adjustments are performed automatically. The duties of the machine-tool operator are generally limited to loading and unloading the machine and "monitoring" the machine during its operation. Technological changes may also be reducing the skills required of *typesetters*. Typesetting machines now can be operated by means of perforated tapes prepared by a perforating machine operator rather than a typesetter. Although the operator must be a skilled typist with a knowledge of typing measurements and terms, he needs much less skill than the printing compositor. The skill requirements of some *intercity truck drivers*, on relatively short runs of less than 400 miles, have been reduced because of easier to drive, multilane, divided highways without steep grades. New highways routed around cities also reduce complex traffic maneuvering. Where *carpenters* work with preassembled building components, such as stairways, windows, and doorways, skill requirements have, in some instances, been reduced.

The effect of this downgrading of skills is more significant than many people realize. We are naturally inclined to emphasize the new occupations created (which will open up new job opportunities), while we overlook the occupations that are declining. The 1960 Census of Population lists more than 80 occupations—many of them skilled—in which employment declined since 1950. These include loom fixers, cabinetmakers, locomotive engineers, paperhangers, plasterers, shoe repairmen, tailors, boilermakers, furriers, stone cutters, and some highly skilled trades in the printing industry.

There is an interesting question as to whether the net effect of all technological changes is to raise the average skill levels in the economy. Some statistics certainly point in this direction.

One piece of evidence is the much greater growth of workers in white-collar occupations as compared to manual workers—especially the very large increase in the number and proportion of professional and high-level managerial workers in the labor force. Furthermore, we know that, among blue-collar workers, craftsmen have grown faster than the less skilled groups. Our data indicate that professional occupations increased from about 8 percent to 12 percent of total employment during the 1950–63 period; salaried managers increased from about 4 to 6 percent. Among blue-collar workers, craftsmen were the only occupational group to increase as fast as total employment, and laborers—who showed almost no numerical increase at all—decreased as a proportion of the total employed work force from 5.9 percent to 5.2 percent. Other statistics pointing in the same direction are those showing the greater growth of nonproduction than production workers in manufacturing, where the proportion of office and other nonproduction workers rose from 19.9 percent in 1953 (when defense production was still heavy) to 21.2 percent in 1955 and 26 percent in 1961. However, since 1961, the ratio was changed little—holding at about 26 percent.

The overall patterns of employment seem to demonstrate that technology, as such, even apart from other factors, is operating to raise skill levels generally. My own judgment is that, on balance, the trend of skills is upward, but I do not have the analytical data with which to answer this question with certainty.

It seems clear that changing technology has resulted in an upgrading of the skill structure of some industries but it has not raised the skill level of many others. In industries that have declined in employment as a result of technological developments, the largest decreases have invariably taken place among laborers and others in the least skilled occupations. On the other hand, in many industries what has taken place is a shift from one occupation to another within the same skill group—for example, within the clerical group a decrease in posting clerks may be offset in part by an increase in key-punch operators.

In any case, *frequency* of occupational change may be as important as the upward trend in skill requirements. A worker who has acquired a certain skill in one occupation may be able to exercise that skill for the remainder of his working life; but he might find it extremely difficult to master a new skill, even though it would rate no higher than the first one. For example, a typist is no more skilled than a lathe operator; that is to say, the training requirements for a new entrant into each occupation could be about the same. However, it might be almost impossible for a lathe operator, 40 years of age, to become a typist; and likewise, a typist might be equally unable to become a lathe operator. So we need not prove that the skill level of the economy is increasing in order to demonstrate that occupational changes can produce unemployment. Any occupational change may have that result.

TECHNOLOGICAL CHANGE AND EDUCATIONAL REQUIREMENTS

If you accept the thesis that technological change does not necessarily raise skill requirements, you may question the need for workers to have more education and training. Nevertheless, I see a growing need for a better educated work force. A good background is becoming more essential, even for those in the least skilled jobs, in order to enable the individual workers to make frequent shifts as technological and other factors increase the tempo of industrial change. This is true, not so much because the duties performed in these occupations require more skill than they did a decade or two ago, but because in our rapidly changing economy, workers in these types of jobs are faced with frequency of change—from one occupation to another, from one employer to another, and from one work environment to another. Employers prefer the worker who can not only perform the immediate job, but who can learn quickly to operate new equipment or perform new functions as the skill mix changes. The girl who can shift easily from check sorter to key-punch operator, to tape-punch operator, to coder, to edit clerk is likely to be continuously employed by one firm or in demand by other employers. Similarly, the young man who can read a bill of lading, follow instructions for loading a truck, use judgment on size of loads, and exercise caution in handling fragile articles will surely be a good candidate for operator of a forklift or other mechanized equipment when it is introduced by his employer. On the other hand, the laborer who has only strength to offer is likely to join the ranks of the unemployed when mechanized equipment takes over material movement.

There is much evidence that an increasing number of employers are demanding a high school education for jobs which formerly were filled by those with less educational background. For example, I have been told that an automobile manufacturer requires a high school diploma for all new male entrants, including those assigned as sweepers. A supermarket chain hires only high school graduates for stocking shelves.

In addition to those already cited, there are a number of other trends which point toward the need for more education and training for our work force. Occupations which require the greatest amount of education and training are increasing most rapidly and the least growth is expected in the occupations generally requiring less than a high school education.

In closing, I should like to stress that, although I have limited my remarks on educational needs to their importance in helping the worker meet the demands of technological and other industrial changes, the social and cultural advantages of education to the individual and the greater contribution he can make as a citizen may be of even greater importance.

EFFECTS OF TECHNOLOGICAL CHANGE ON THE NATURE OF JOBS

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THE TERMS "technological change" and "automation" have won prominent places in our national vocabulary in the past decade. They have been the subject of much discussion, debate, and concern as reflected in congressional hearings, union negotiations, and special reports to the President. Much of the comment has been directed toward the problems arising out of technological change—obsolescent skills, job displacement, need for retraining, and other symptoms of occupational maladjustment.

A critical aspect of the problem is the rapidity with which technological change is being applied. Substantial increases in expenditures for new plant and equipment and on scientific research in the post-World War II period resulted in an acceleration in the rate of technological advance. During the 1950's alone, new plant and equipment expenditures totaled the astronomical sum of $300 billion. As a result of this regeneration of American industry, the Nation has acquired a more efficient capacity to produce. Between 1947 and 1963, productivity in the nonagricultural sector of the economy increased by 2.4 percent a year, compared with a long-term rise of 2.1 percent; in agriculture, productivity advanced about 6 percent a year.

At the same time, this huge flow of investment continues to result in mass obsolescence of existing plant and equipment, outmoding of existing techniques and methods of production, and the development of new and substitute materials. Use of new materials and the emergence of new products result in a significant change in the occupational composition of the work force and require new skills to be developed.

These economic changes have had significant implications for the industrial and occupational structure of the Nation. Industrywise, 1956 marked an important turning point. For the first time in the Nation's history, there were more white-collar workers than blue-collar workers—more people engaged in trade, service, finance, government, and transportation and communication than in agriculture, mining, manufacturing, and construction. Gains in manufacturing employment have lagged in the past decade in the United States along with the number of direct production workers in industry. The employment increases that have been taking place in manufacturing have been relatively larger in marketing and sales, in research and engineering, in clerical and bookkeeping operations, and relatively smaller in direct production work.

These far-reaching changes in industrial employment opportunities have had a direct impact on the occupational structure. Workers need more skill, more technical know-how, and more educational attainment. In the last 30 years, the professional segment of the labor force has expanded by about 50 percent, growing faster than almost any other major occupational group. Another category of occupations—the technician—has emerged which is so new that it has not yet been completely described or defined. Today there are twice as many groups in the occupational classification structure for professional, technical, and managerial occupations as there were in an earlier compilation prepared some 10 years ago. Part of the gain is attributed to an increase in the number of new types of jobs with the other part due to the changing importance of job groups in which relatively obscure occupations, by virtue of expanding employment, have earned their own group identity.

So rapidly have occupations emerged and job identification changed in the United States that the new edition of the U.S. Employment Service *Dictionary of Occupational Titles* (D.O.T.), which is the codification of 22,000 observed jobs in our industrial structure, contains about 6,000 jobs which were not present in the preceding dictionary.

Over the years, first-hand experience by the public employment service system with the structure and mechanism of the job market has resulted in a number of general observations relative to the effects technological change has wrought on the nature of jobs.

With the advent of more technology, the relationship between occupations and industries diminishes. The same method and the same kinds of workers can produce a greater variety of products. Many occupations are cross-industry in nature, which means that workers can transfer from one industry to another, or the plant in which they work can change over from one product to another, with no change in occupational content.

Technology is changing the content of occupations. At the professional and skilled levels, there is a stronger tendency to combine new disciplines and knowledges.

Some occupations have become obsolete and are tending to disappear. These are usually the simpler types that involve processes replaced by automation, as well as the lower levels of supervision and management. They are not entirely obsolete, however, because people remain employed in these jobs. For this reason obsolescence is difficult to define. One operational definition describes an occupation as obsolete if there is little or no chance of placing an applicant in that occupation. Therefore, the significant change taking place is in the numbers of persons employed in the occupation.

Many new jobs are generated by new technology and invention. Examples would include the nuclear engineer and the galaxy of technicians that have appeared to fill the gap existing between the skilled craftsman and the professional scientist and engineer.

Technology changes the physical and mental demands of jobs. Automated processes carried on by remote controls or tapes performed in office-type surroundings may indeed open many jobs to women or the handicapped. On the other hand, performance in these jobs may well call for more alertness, education, and training.

Emergence of the team approach appears to be a necessary concomitant of automation. Advanced technology gives rise to stress on management and supervision, particularly because equipment is expensive, processes have become technically more complicated, and coordination of effort is a necessary part of job performance.

I

TECHNICAL CONCEPTS

Definition of Technological Change

In order to discuss the effects of technological change on the nature of jobs, it is desirable that the terms "technology" and "technological change" be defined. For the purposes of this report, "technology" refers to those techniques by which available economic resources are transformed into goods and services needed to fulfill human wants. Thus, in discussing "technological change" we are concerned not only with the invention of new types of laborsaving machinery and devices but also with changes in the handling of materials and the flow of work, changes in the resource mix used in production, the development and application of new and substitute products and materials, and various managerial efficiencies. All of these changes have their impact on and are reflected in the occupational structures of industries and the duties of occupations and jobs.

A brief discussion of the occupational investigation techniques developed by the U.S. Employment Service is a necessary preliminary for a fuller understanding of our findings on the impact of technological changes on jobs and the conclusions that may be drawn from these findings.

Studying Nature of Jobs

When the Federal-State Employment Service first began operations in 1933, it was well recognized that there was no significant body of definitive information about occupations and jobs. At that time local offices developed their own information about occupations, and gave their own meanings to job titles for use on applications and employer orders. There was no common language for the exchange of information among employment service personnel within local office processes or between offices.

It was against this background that an occupational research program was initiated in 1934. A small group of technicians began collecting occupational information about jobs in a few industries by direct observation of persons at work at their worksites. From these data, comprehensive job descriptions were prepared. By 1935, 15 occupational research centers were established throughout the country and continued in operation until 1939 to speed up the collection and dissemination of such information for use in the public employment service system.

Although developing standardization of job titles was one of the first and major objectives of the occupational research program, it became evident that other occupational data were needed to facilitate activities concerned with assuring full utilization of workers' knowledges and abilities and to assess the job potentials of entry workers lacking identifiable skills. After some trial and error in the early years, the basic concepts of job analysis had crystallized by the end of the thirties into an accepted technique that continues in use today, not only in employment service operations but to a considerable extent in private industry as well.

Job analysis is the process of determining, by observation, interview, and study, the significant worker activities and requirements and the technical and environmental factors of a job. It is the identification of the tasks which comprise the job and of the skills, knowledges, abilities, and responsibilities required of the worker for successful job performance. Job analysis indicates the exact nature and scope of the tasks involved in a job and defines the level of difficulty of those tasks. The first three parts of the job analysis formula, the "What," "How," "Why," bring out the nature and scope of the tasks. The last part of the formula, the "Skill Involved," measures the degree of difficulty of the task and defines the nature of the required abilities in order to indicate their level of complexity.

Despite the many problems of the early years, the public employment service made progress in improving its operations and developing the tools and techniques that were essential to providing more effective service. Technical and developmental work went forward in the fields of job analysis and job identification, occupational classification, aptitude and proficiency testing, and job market information to meet the growing operating needs of the local offices for occupation information. The publication in 1939 of the *Dictionary of Occupational Titles* provided an indispensable tool for the understanding of job content and job relationships and for all future work in occupational research, though its significance and potential was not fully foreseen at the time. It had developed out of the apparently simple and obvious need to identify and classify the skills of job applicants and the requirements of job openings on a standard, uniform basis so that they could be appropriately matched.

The techniques of job analysis were soon put to new and unexpected uses. With the onset of World War II, labor shortages replaced widespread unemployment. Job analysis techniques were used to identify groups of related "families" of jobs that facilitated the transfer of workers from less essential to war production; and it made possible the use of handicapped workers, women, and older workers in many jobs which they had previously been considered unable to perform. It provided the means for dividing complex occupations into a number of simpler operations that could be performed by workers with a minimum of training. Thus, job analysis itself became a tool that contributed to technological change.

In addition to data already available from the occupational research program, byproducts of job analysis were developed by the U.S. Employment Service, then a part of the War Manpower Commission. The manning table program, designed to facilitate the orderly withdrawal of workers from essential industry to the Armed Forces, was introduced. Manning tables provided a technique whereby employers could inventory their manpower needs and arrange for training programs to provide replacements for workers being released for induction into the Armed Forces. Plant and industry staffing schedules and manning tables contributed to standardizing training time and to evaluating manpower requirements in war production plans. Occupational composition patterns, which were composites of plant manning tables, were developed for selected basic war industries, such as ordnance and shipbuilding, to establish staffing patterns and to plan recruitment for new plants.

"Occupational Guides" based on expanded job descriptions prepared during World War II and containing a current job market information supplement were released to local offices to serve the needs of counselees, particularly veterans released from military service. To further assist veterans, separate publications were developed to facilitate placing Naval personnel and Army personnel in civilian jobs. These publications consisted of a series of job families relating civilian jobs to military training, similar to the series for jobs primarily of importance to the war effort which were published during the early war years. Also released during this period were handbooks concerning scientific and other specialized occupations, and physical demands information associated with craft occupations and other selected jobs. In the meantime, volumes of job descriptions were prepared as data were collected for selected industries and broad occupational categories.

A new occupational research technique emerged when experimental work was undertaken in the late forties to develop a new occupational classification structure that would reflect relations among jobs in terms of more than the traditional "job" content. Eight classification components were selected as significant for identifying such relationships: Training time, aptitudes, interests, temperaments, physical demands, working conditions, industry, and work performed. A sample of 4,000 jobs from the D.O.T. was analyzed in terms of these components, and the results were studied to discover component relationships. In 1957 an interim research document, the "Estimates of Worker Trait Requirements for 4,000 Jobs," published the experimental estimates for the first seven of the classification components listed above. This analytical technique added important information to the study of changing and emerging jobs and their requirements, as exemplified in this report. The new occupational classication structure resulting from this research will appear in the third edition of the D.O.T., to be published in 1965.

As technological developments brought changes in the occupational structure of the labor force, an urgent need emerged for more occupational research and analysis. New arrangements were made to continue the research program in the field, and special projects were initiated in 1953, with 17 State agencies participating. The major objective was to obtain and keep up to date the changing information about jobs in the American economy.

In 1958, Occupational Analysis Field Centers were established in four States (California, Michigan, Missouri, and New Jersey) and the District of Columbia. Within 2 years, three more centers were established (North Carolina, Washington, and Wisconsin). All work assignments to the centers were directed toward verifying and revising the job information in the D.O.T. for a third edition. A modified job analysis technique was devised to raise the quality of D.O.T. verifications and resulting job definitions. Included in the modification was the obtaining of information on the eight classification components mentioned above. In addition to the field centers which are still in operation and which largely replaced the "special projects" established in 1953, there are special project activities currently in operation in five State agencies (Arizona, Connecticut, Ohio, Minnesota, and Texas).

Nature and Scope of Data Collected

Between 1934 and 1939, over 125,000 analyses of jobs were prepared in over 25,000 establishments. These data provided source material for the preparation of a variety of occupational materials including the many volumes of job descriptions and the 1939 edition of the *Dictionary of Occupational Titles*. These materials provided the first extensive compilation of job information for the U.S. economy. They are the basic data from which subsequent technological change and its effect on jobs can be identified and measured. In the years following, additional job analysis data were gathered and a second edition of the dictionary was prepared in 1949, and a supplement to this edition in 1955. These materials, however, were largely additions to the existing data rather than revisions.

In 1965, a third and completely revised edition of the dictionary will be published. For the first time there will have been a complete verification of its contents. Over 45,000 individual job studies were made to obtain current coverage on the occupations found in the industrial economy. Since many of these studies were based on observations in more than one plant, the total number of job observations made was over 75,000. In addition, thousands of reports have been received in recent years from all 50 State agencies describing jobs which operating personnel could not find or classify in the D.O.T. These have added to the fund of information available, and frequently drew attention to new groups of occupations. For example, as a result of receiving this information, "Occupations in Electronic Data-Processing Systems" was published in 1959. All of this information will be reflected in the 23,000 jobs defined in the new edition of the D.O.T. Comparison with information in previous editions will show the changing nature of jobs since the 1930's.

Job analysis techniques have been utilized in studying the jobs in a number of industries before and after the introduction of technological innovations. Also, the employment service system has undertaken a number of experimental demonstration projects in individual local job markets to determine the impact of technological change on employment. Such projects have been initiated in 16 States involving 20 industries and 27,000 workers.

II

THE CHANGING CONTENT AND REQUIREMENTS OF JOBS

General Considerations

It can be stated that the most significant changes in the nature of occupations are caused by new machinery, tools, and equipment. Such technological changes occur in all areas of economic activity, including: (a) Manufacturing, e.g., utilization of numerically (tape) controlled machine tools; electronic, electrical, and other sensing devices for inspection purposes; instrumentation to measure minute dimensions and quantities; and more efficient materials-handling and continuous-processing equipment; (b) commercial operations, e.g., utilization of computers for information processing and problem solving; (c) agriculture, e.g., new machines for planting, cultivating, harvesting, and field packing to reduce the manual and hand labor previously required; (d) mining, e.g., continuous mining machines; and (e) construction, e.g., large power shovels, tractors, bulldozers, and straddle carriers.

The categories of jobs most seriously affected by technological changes are the traditional production positions, such as those involving machine tending, feeding, and offbearing; materials handling; and materials processing. Routine clerical tasks also are being affected to a considerable extent. Electronic sensing devices are replacing human judgment in connection with the inspection and quality-control processes—reducing the direct application of human energy, skill, and control. It is with respect to jobs chiefly in these areas that the more profound changes are taking place.

At the same time, a smaller number of jobs involving distinctly new and higher levels of complexity are coming into being. Equipment design, maintenance, and repair; production scheduling; coordination of highly integrated mechanisms; and systems analysis, programing, and engineering are occupational areas now reflecting new job categories or refinements of traditional occupational areas. The health physicist, for example, engages in research, training, and monitoring programs to protect plant and laboratory personnel from radiation hazards. (See app. II, item 1.) The optical-missile-tracking technician tracks missiles on downrange flights. (See app. II, item 2.) A nuclear medical technologist prepares, administers, and measures radioactive isotopes in therapeutic, diagnostic, and tracer studies. (See app. II, item 3.) The systems analyst analyses data-processing problems to device computer system requirements, plan machine layouts, and develop programming procedures. (See app. II, item 4.)

The stress on research, design, and development has increased the need for scientific and engineering skills beyond the available supply of fully qualified professional workers. Also, the fact that engineers and scientists are devoting more time to theoretical work and less to the practical application of their theories has necessitated development of technical supporting personnel to relieve the professional staff of certain tasks and duties. A large group of technicians, therefore, has been created who require technical and related training of a nature to provide direct support to the engineer or the scientist in the areas of research and development, quality control, testing, or the maintenance and repair of equipment. (See app. II, item 5.)

Since many manufacturing techniques and processes require the use of a variety of technologies and scientific disciplines, it is now necessary for many establishments to hire a number of different experts, such as electrical and electronic engineers, physicists, operations planners, computer experts, design and systems engineers, and maintenance specialists, and to rotate them to various areas in the plant to develop generalists who can relate all separate activities into an organized whole. (See app. II, item 6.)

Job Changes Due to Changes in Materials-Handling Techniques

The introduction of automatic transfer equipment and conveyor systems is making obsolete the jobs of unskilled materials handlers and creating a need for maintenance men with wider ranges of knowledge. Electricians now must have a knowledge of electronics, and machine repairmen a knowledge of hydraulic and pneumatic systems. However, advances in materials handling have not been confined to the manufacturing industries; they also have been introduced in such nonmanufacturing activities as agriculture, mining, and retail trade. For example, there is now in existence an automatic warehouse in which cartons and goods are conveyed automatically to and from the storage area and delivery platform. A worker known as an automatic conveyor-line operator controls automatic palletizing equipment from a console to sort, transfer, and stack products. (See app. II, item 7.)

Laborsaving devices also have been introduced in supermarket backroom operations. Such devices weigh, label, and compute the price of merchandise; stock items such as detergents, beer, soda, and other heavy and bulky merchandise; and prepackage meat, fish, poultry, and produce, thereby eliminating such time-consuming tasks from the jobs of clerks and other supermarket personnel.

In the concrete, gypsum, and plastics products industry, the utilization of conveyors, layer lift trucks, and mobile cranes has increased. In the preparation of ready-mixed concrete, a rubber-coated nylon container allows the shipment of properly proportioned amounts of aggregate, cement, and water to the site of special construction jobs. In the high-production foundries, management is considering installing pneumatic tubes for the distribution of sand and dry board materials. A reduction in the amount of hand labor required to load, transfer, and unload bulky and heavy material is a natural consequence of the installation of such devices. Job duties involving lifting and carrying heavy objects are fast becoming obsolete.

Job Changes Resulting From Process Automation

In the modern petroleum refining plant, operating personnel are concerned with monitoring the process through batteries of instruments. Formerly, these workers were required to adjust valves on the processing equipment and, in so doing, were required to spend time working outdoors, walking through the plant area, or climbing structures to gain access to valves and other controls. Now workers known as control men observe instruments for readings of pressure, temperature, and tank level, record these readings, and alter the settings of dials, switches, and levers from control panels. (See app. II, item 8.) Workers perform their duties in independent, officelike control rooms, with instruments and panels of switches and knobs on the walls close to the processing units with which they are concerned. No moving equipment, pipes, or tools are visible. There is no direct contact with the material being processed.

From a central control room an entire steam plant is started, operated, and shut down by one steam plant operator. (See app. II, item 9.) At one plant, this new job made unnecessary the jobs of turbine operator; turbine attendant; powerhouse runner; switchboard operator; and generator operator [1] formerly associated with the operation of boilers, generators, and power switchboards. The operator adjusts automatic remote controls to boilers and auxiliary equipment, such as pumps and compressors, and sets controls on a panel board to maintain specified pressures and temperatures. Closed circuit television is used to monitor equipment and detect malfunctioning. The plant has integrated automatic devices so that if power demand lessens, a signal decreases steam pressure, which in turn reduces boiler air, water, and fuel consumption. Alarms are imbedded in all pumps, pressure lines, and other equipment. If equipment does not function within critical limits an alarm rings and a red light appears on an alarm system directly over the automatic controls. Also, closed circuit television focuses on the fires from each burner in the boiler so that the operator can see if the integrated system is operating according to specifications. No security guards are required because the operator can observe all entrances and gates leading into the plant over closed circuit television. The operator, utilizing a two-way communication system, can admit anyone into the plant by turning controls that activate gates or entrances.

Job Changes Resulting From Changes in Computer Technology

Electronic data processing has opened up new fields of employment, creating new sets of job duties and modifying existing ones. In many instances, it has been possible for industry to retain its existing work force with little or no dislocation of its employees. However, technological changes, plus improved systems and procedures analyses, have reduced the need for workers capable of performing effectively only in routine clerical jobs, and increased the demand for workers with the flexibility, education, and desire for self-improvement to cope with the increasing rate of change in clerical and technical occupations. Many clerical workers with knowledge of company organization and workflow have been trained as programers. Such jobs require the worker to convert symbolic statements of scientific or technical problems into machine language for solution by data-processing equipment. (See app. II, item 10.) Tabulating machine operators have been the personnel most frequently chosen for training in monitoring and controlling computers and peripheral equipment. Such persons formerly placed punched cards in the feed magazine of a tabulating machine, and adjusted the machine for specific arithmetic functions. They now are called console operators and monitor and control the electronic computers and auxiliary equipment such as automatic typewriters to maintain business records and solve technical problems. (See app. II, item 11.) Changes in personnel needs and in job duties will be a continuing aspect of technological advances that are to come, as new equipment and applications are developed.

Electronic data-processing equipment has had a significant impact on job duties related to commercial operations. Such equipment is used by banks, mail-order houses, insurance companies, and many other types of commercial establishments to process vast quantities of data involving subscriber information, inventories, and related business accounts; by manufacturers for both management and production operations; and by government agencies and private universities not only for operational purposes but also for solving technical problems associated with research activities.

The effect of electronic data processing on operations in the banking industry can be inferred from the experience of one banking organization which, in 1961, had 1,560 employees on its payroll. Installation of an electronic data-processing system enabled the bank to develop and expand its customer service, which handles payroll and operational paperwork for large organizations and department stores. As a result, after 2 years the number of employees had jumped to 2,200. Although installation of the system eliminated the central bookkeeping department, with consequent displacement of approximately 50 bookkeepers, these persons were soon absorbed through the bank's own intensive retraining program.

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[1] The meanings of job titles not included in the appendix are those contained in *Dictionary of Occupational Titles*, 2d. ed. (Washington: U.S. Department of Labor, Manpower Administration, Bureau of Employment Security, 1949).

In the paper and pulp industry, the application of computer controls to the digestion process in the treatment of wood chips is the first step toward complete computer control of all processing of paper and pulp in the plant.[2] Computers have taken over the critical adjustments of the rolling mill in the iron and steel industry, regulating the temperature, pressure, and speed of rolling. Such tasks formerly required considerable training and experience on the part of the human operator.

In the baking industry, the computing machine system monitors the bulk storage of ingredients; controls batch blending and mixing, time cycles, oven temperatures, speeds of conveyors and other equipment; computes the number of rolls to be delivered to customers; processes payroll of employees; computes market prognosis; and monitors product changeovers in accordance with market prognosis.[3] Workers whose jobs were concerned with blending and mixing ingredients by the operation of individual machines have given way to those who monitor control panels. The continuous process method of baking bread is replacing the conventional method, which required several hours for the dough to rise. While the yeast fermented, the dough had to be punched or kneaded several times to release some of the gas generated by the growing yeast plant. Dough batches weighing up to 1,200 pounds had to be handled, mixed, punched, flattened, rolled, divided, and dropped into pans. The process took about 5½ hours. In the newer method, yeast is fermented in a broth with water, milk solids, salt, sugar, and enriched ingredients for 2½ hours under the direction of a worker at a control panel.

Insurance companies have installed electronic data-processing and data-transmission equipment to reduce clerical routine work. Automatic reading devices for premium collections, check writing, and handling operations reduce the amount of input preparation done by workers such as keypunch operators, and greatly reduce the routine type of clerical activities. Data-transmission systems are used to send information from field offices to home office computer centers or to link distant computer centers.

Job Changes Following the Development of Numerical Control

In some operations, such as metal working, the trend toward tape-controlled machines is eliminating some activities requiring highly developed machining capabilities. Functions formerly the responsibility of the machine operator and setup man are being transferred to engineers, tool designers, technicians, and tape programers.

One such tape-controlled machine automatically changes cutting tools and indexes the table through impulses received from a code punched in the control tape. A program is prepared by a tool programer who decides what tools to use, how a casting should be set in the holding fixture, the sequence of machining operations, and positioning of the casting in relation to the tool. (See app. II, item 12.) This information is punched in the tape and then sent to the production shop, along with the tools and process diagrams. The machine operator installs the tools and tape and starts the machine. From this point on, all movements of the machine are controlled by the tape. The need for separate machine setups required to drill, ream, and tap castings has been eliminated. The relationship of a worker to his machine has changed, in some establishments, from that of a skilled operator to that of a tender or machine watcher. An example of this is the tape-control drill-press operator. (See app. II, item 13). Where once considerable skill was required to set up a metal-working machine, including indexing of table or work piece, and achieve fairly high tolerances, both skills are now automatically built into the machine which is guided by a length of punched tape. The operator verifies finished dimensions but often is required to notify a supervisor when dimensions do not meet specifications, rather than make the necessary adjustments himself.

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[2] "Computer Controls," *Automation*, Vol. II, No. 2 (February 1964).

[3] Alice Mary Hilton, "Computers Replacing Repetitive Task, Workers May Create New Society," *The Baltimore Sun*, Aug. 10, 1963, p. 4.

Job Changes Resulting From New Machines, Processes, and Techniques

In 1956, for the first time in its history, this country had more white-collar than blue-collar workers. This Nation started out primarily with farmers and a few craftsmen and merchants. At the turn of the century, one out of every three people was living on a farm. Less than 1 out of 10 lives on a farm today in the United States. There is a popular conception that technological change and advances in mechanization are generally associated with urban industry. In recent years, however, changes in agricultural machines and techniques have revolutionized agricultural activities.

For example, there has been a declining demand for unskilled "hands" and an increasing demand for skilled workers. This is due to the need for job knowledges pertaining to special mechanical operations. The use of new machines to harvest and process agricultural products has increased the demand for workers who can operate, maintain, and overhaul a variety of farm equipment, such as tractors, harvesters, pumps, and tilling equipment. (See app. II, item 14, Farm Equipment Mechanic.) In addition, such persons often install and repair farm electrical and plumbing systems and construct and repair buildings and other farm structures. Planting, weeding, cultivating, and harvesting of a number of crops are already mechanized, but the extent of mechanization varies throughout the United States because of factors adverse to mechanized operations, such as climatic conditions, type of terrain, ground conditions, or failure to train the growth of plants in such a manner as to facilitate harvesting. (See app. II, item 15, Farm Equipment Operator.)

The introduction of mechanization and new techniques in the electronics industry has eliminated many time-consuming tasks. Handwiring of circuits for use in such equipment as radio and television sets and in aircraft and missile-control system is being replaced by printed, etched, or stenciled circuit boards. (See app. II, items 16–17.) Instead of the routine task of assembling and soldering wiring, workers now print and etch conductive patterns on copper-faced plastic boards, using photoengraving and etching equipment. Machines install electronic components such as resistors, capacitors, and diodes on the circuit boards. A worker known as a component-inserting-machine operator now loads parts into the feeding mechanism of a machine and depresses a pedal that bends the lead wires of the parts and inserts them into holes in the circuit board. This is replacing the tasks of those workers who connected the components into the circuit and soldered them in place, using handtools. (See app. II, item 18.)

The impact of machinery on coal mining jobs also has been significant. The pick-and-shovel miner is being replaced by miners who operate mechanized cutters and conveyors, and even by a "miner" who sits in a control room outside the mine and guides the cutter and conveyor belt through the mine by means of dials, gauges, throttles, and buttons.

In the concrete production and construction industries a rapid changeover is taking place with respect to the mixing of concrete. A console-controlled system is replacing the manual (lever or pneumatic controlled) technique. (See app. II, item 19.) The manual system depended heavily on the ability and judgment of the operator to maintain the quality and consistency of the product. Requests from customers for batches of concrete of varied consistencies taxed the ability of the manual operator who compensated for variables by judgment based on experience. Variables, such as size of aggregate, amount of materials, and moisture content, in the new system are all regulated by controls in the console. An operator presets specified mix weights on console controls by turning setscrews or punching out mix formulas on punchcards and inserting cards into the console slot. The caliber of the operator and maintenance men, therefore, has changed. Both now need some knowledge of electronics and the ability to work with electronic equipment. The retraining of operators seems to vary, depending on the individual's aptitude (and perhaps his attitude) for console work. In one plant, a very good manual operator could not cope with the battery of flashing lights, dials, pushbuttons, scales, knobs, meters, and switches, and was transferred to another job in the plant.

Mechanization has introduced a "new" industry into the economy. Not until the advent of the shrimp-peeling machine was it economically feasible to exploit the valuable quantities of shrimp existing off the coasts of Washington, Oregon, Alaska, and British Columbia. The relatively small size of Pacific Pink Shrimp precluded efficient hand-peeling methods. A worker known as a peeling machine operator sets up a machine according to the size of the shrimp to be processed, starts the feed conveyors, and inspects the processed shrimp to determine the efficiency of the peeling and heading operation. (See app. II, item 20.)

A more comprehensive analysis of the effects of introduction of technological innovations on plants in the printing and publishing industry is presented in appendix I. This case study shows the impact of automated equipment on occupations, manpower, and training requirements in six composing rooms and two binderies.

Changes in Physical Activities and Work Environment

Automation and technological progress has had an effect on the physical and mental demands of jobs and on the work environment in which jobs are performed. Most jobs of the future will be performed in offices or in clean, officelike rooms where processes will be carried on by means of remote controls. Such jobs will demand more education and training than those they replace. Technological advances, in this respect, have special significance where the employment of handicapped workers is involved, since the physical effort and activity required of workers is being steadily reduced.

For example, a lumber manufacturing establishment recently installed two highly mechanized pieces of equipment in its sawmill. In this mill, conveyors and other mechanical equipment transfer, turn, or move logs and lumber, and control devices set specifications and activate and operate machinery. The physical tasks of workers such as offbearers, lumber straighteners, turners, feeders, helpers, doggers, tailers, and block setters have been almost entirely eliminated. Workers, now stationed behind panel boards, control the operation of more sophisticated equipment. Their tasks relating to the physical operation of the machinery consist primarily of pressing specification and actuator buttons, pulling switches, and pressing pedals. (See app. II, items 21, 22, 23.) More premium is placed on motor coordination and finger and manual dexterity, since achieving a production rate depends on rapid manipulation of buttons and controls, as well as on a knowledge of lumber, and the ability to make quick and accurate decisions.

In the automated plant, therefore, there is less physical effort and less handling of heavy materials. The integration of discrete units of equipment also means integration of jobs, so that workers tend to control a wider range of machine functions as they become responsible for a larger span of the line.

The elimination or reduction of physical effort in many jobs has been offset by a corresponding increase in mental activity. Workers concerned with the operation of an electronic computer system, for example, develop a considerable amount of nervous tension because of the accuracy and attention to detail required in programing, the responsibility for the functioning of delicate mechanisms, and the urgency for avoiding interruptions in the work through errors or malfunctioning which would cause expensive shutdown of equipment.

Other jobs which engender mental strain are those high-speed operations which require continuous and close attention by the worker. Often overlooked is the fact that many automated jobs are now repetitive-type tasks which demand vigilance on the part of the worker, but little else. The tasks are uniform and lack technical interest, but require close attention to detail to keep the machines functioning accurately and smoothly. The uniformity and excessive simplification of the duties of many machine operators, and the extreme subdivision of their functions which further limits their area of activity, can induce physical and intellectual debility, irritability, and various other functional disturbances in the worker. The employment service is becoming increasingly concerned with practical preventive measures with respect to problems arising from the demands of many of these new jobs. Careful selection of personnel from the standpoint of mental as well as physical suitability is being emphasized, and considerable stress is being placed on the importance of medical and psychological selection factors for workers assigned to mechanized operations.

Another area under investigation by the employment service is the psychological effects on personnel working in isolation from others. More and more workers are sitting in control rooms monitoring equipment, with no one around to "shoot the breeze with." Isolated workers such as the "lookout" in a forest preserve or a lighthouse keeper can, at least, move around and relax to a considerable extent. A monitor in a control room, on the other hand, must keep his eyes on panel lights, dials, and other controlling and recording equipment at all times to prevent damage to product or equipment. Further inquiry into this problem may result in modifications of procedures and equipment design, as it is doubtful that careful screening of personnel, as mentioned above, is the only answer.

Mechanization is improving the work environment and bringing about better safety and health conditions. Automatic equipment and controls have decreased industrial accidents, and injury rates in highly automated plants are low. This is the result of mechanized materials handling, elimination of hazardous jobs, and reduction in the number of people concerned with direct production. For example, dangerous operations can be monitored now by electric eye or television equipment. Also, workers need no longer be exposed to air contaminants, because manufacturing operations are enclosed and workers are stationed at control panels completely isolated from the processing area. Such factors as ventilation, temperature, humidity, and noise are becoming less significant in affecting the worker's performance. Surveys are being made of disturbing influences that impair or reduce accuracy and speed of human activities. The demands made on personnel maintaining and servicing equipment are being investigated to plan the location of work areas, and installation of control and indicating devices to insure the safety and health of personnel setting up and repairing equipment.

III

IMPLICATIONS AND CONCLUSIONS

Technological change can be expected to continue its accelerating pace. Change in the nature and content of jobs will be an inevitable consequence of changes in machines, processes, techniques and materials. Actual measurement of the impact of this change on the American occupational structure varies according to the special interests of those attempting to measure it. Typical techniques appraise shifts in products or processes, output per man-hour, gross employment changes, or the reengineering of production lines. The special interest of the U.S. Employment Service, on the other hand, is directed toward the human resource element—the impact of technology on people. It is concerned with the identification of those affected and the utilization of existing skills; or, where that is not possible, their redirection through training or job mobility to other gainful activities.

This issue—manpower conservation and utilization—has been building up for more than a decade. The upheaval in the job market is so tremendous that the Nation has yet to take the measure of its social, economic, and political impact. In recent years the U.S. Government has faced up to this challenge and since 1962 there have been epoch-making advances in legislation for the conservation and development of our human resources. The Area Redevelopment Act and the Manpower Development and Training Act programs require information on training opportunities, and the Vocational Education Act of 1963 imposes a need to provide longer range training goals. In meeting these requirements, the U.S. Employment Service must act as an early warning system to educators by providing the first signals of job changes that will affect vocational education and training. Selective service rejectees need to be oriented in expanding job opportunity fields, and the Economic Opportunity Act of 1964 requires information on occupational opportunities, largely for disadvantaged youth. In all of these new developments the role of the U.S. Employment Service has been greatly expanded.

The USES has taken leadership in job market and job analysis. Gearing our surveys to take account of local differences—industrial and geographic as well as local mores, seasonality patterns, manpower capabilities, and the like—we have taken the measure of the thousands of local job markets which together make up the national mosaic. In developing data relating to current and future labor supply and to changes in the occupational structure, it is necessary to gather such data in terms of specific occupations. We have developed a system whereby jobs can be studied at regular intervals at the same plant, e.g., every 2 or 3 years. In this way, a comparison of staffing patterns, process descriptions, and job studies will show new operations and the new or existing jobs that are or will be affected by the changes. Also gathered will be information on job relationships between existing and new jobs, and data will be obtained on transfer, promotion, and training practices used in any changeover to a new system. In this way, trends can be recognized and plans made for efficient training or retraining programs. Job vacancy information by occupation will be obtained in at least all major localities on a recurring basis. Detailed supply-demand information is required on important occupations in all major metropolitan areas, with special emphasis placed on scientists, engineers, and technicians. Occupational inventories for major employment centers, perhaps every 2 or 3 years, will permit a base for long-range forecasting and better evaluation of occupational demand and supply.

The enormous changes taking place in the job structure of the American economy require a reorientation to our approach in preparing people for work. All the experience amassed by the USES underscores one fact: Of all the resources needed for the Nation's economic well-being and advancement, its human resources require the longest leadtime to becomes effective. It takes years—20 or more—for a child to grow into a mature and useful adult and a competent member of the labor force. However, his vocational preparation does not end here. Because occupations are changing at an increasing rate, workers must be prepared to change with them. People will be changing careers—not jobs—three to four times in a lifetime. In this setting, job preparation cannot be limited to the acquisition of individual job skills. It must prepare the individual for greater flexibility with respect to the range of jobs for which he is potentially suitable. A worker must plan his career in terms of a progression of occupations with periodic retraining to keep abreast of changing methods and techniques, application of new materials, and related knowledges required.

These conditions have challenged the U.S. Employment Service to report its occupational information dynamically, and at the level of specificity or generality appropriate to its purposes. One example of how this challenge is being met is the forthcoming revision of the *Dictionary of Occupational Titles.*

The definition of a job in the D.O.T. has the appearance of something static; it consists of facts rather than trends. However, if you look at a group of related jobs as they appear in the classification structure of volume II, you may find that several different jobs exist to accomplish the same purpose. Under a division called Metal Machining Occupations you will find that machining is done in a large production plant differently from the way it is done in a small job shop. In the small job shop one man sets up and operates his own machine. In the large production plant a highly skilled setup man will set up a large number of machines which will then be fed or tended by a number of workers of lesser skill. In another dimension you will find the same machining function being accomplished as it was 50 years ago by a skilled operator, and as it is performed in a modern manner on a machine operated by a roll of magnetic tape. As all of these methods exist simultaneously in our economy, they are all presented simultaneously in the dictionary.

We must communicate occupational information at the level of specificity or generality appropriate to our purpose. When our purpose in the U.S. Employment Service is to place an applicant in a job that will utilize as much of his skill and experience as possible, or when we want to meet as precisely as possible an employer's requirements for a worker, our information must be specific. This is why the information in our job definitions and our method of classifying occupations is as precise as we can make it. On the other hand, when we are counseling a youngster who has the whole world of work to choose from, such specificity would not be appropriate. For this reason we are including in the third edition of the dictionary a new section called "The Worker Traits Arrangement of Job Titles." It will present an additional arrangement of all jobs in the dictionary, grouped in terms of commonality of worker traits. The worker traits information, including aptitudes, interests, temperaments, training time, and physical demands, will not be presented in precise terms for each job. Instead, the information will be presented in terms of a range of worker traits generally required by a group of jobs. There will be about 100 such groups. The resulting information will be at the level of generality appropriate to developing a worker's flexibility and relating him to a range of jobs for which he is potentially suitable.

The classification structure of the new dictionary is abandoning the separation of skilled, semiskilled, and unskilled occupations and that of professional and semiprofessional occupations. Instead, all occupations pertaining to a particular subject matter or work method will appear in the same group and will be arranged within that group in order of level of complexity. This will present in each group a picture of a possible job ladder from the entry jobs up through jobs requiring an increasing degree of skill or knowledge.

The classification structure of the dictionary will be sufficiently flexible to accommodate new kinds of occupations as they develop. This will permit the structure to have a long enough life to provide continuity in the reporting of occupational information. The key is a coding system in which the purpose of a job (such as machining or child care) is always reflected in the first part of the code number and the function of the worker (such as operating or serving) is always reflected in the last part of the code number. Thus, if a machine is ever invented to care for children, and the child-care attendant becomes a machine operator, it is only necessary to combine the existing code parts for "child care" and for "operating" to code the new job and place it in the classification structure.

As the world of work changes, our techniques for studying the changing nature of jobs also will undergo modifications. Considerable emphasis already has been placed on the mental aspects of jobs and on the traits required of the worker for successful performance. Future job analysis studies may well tend to focus on the psychological aspects of jobs, namely, factors and conditions that result in satisfaction or dissatisfaction, feelings of creativity or boredom, constructive participation in the work effort, or passive job performance. The challenge has been made—we must accept.

APPENDIX I

PLANT EXPERIENCES WITH INTRODUCTION OF AUTOMATED EQUIPMENT

PLANT I

This plant has installed automatic folding machines. After installation of this equipment, the hand operations of folding were eliminated, thus displacing three workers classified as folder, hand. The displacement of six workers functioning as folding-machine operators resulted from the automatic nature of the new folding equipment, which does not require workers to control directly the folding operations. What is required, however, are workers to set up the equipment, and monitor its operation during the course of a folding run. In this case, a new job, that of folding-machine setup man was created, thus partially offsetting the elimination of folding-machine operators. A decrease was recorded in the number of workers employed as folding-machine feeders, and takers-off. Continuous operations which replaced operations previously done separately account for this decrease.

The employment level in the gathering department was unaffected by the installation of automatic gathering machines because of increased production. The effect of this installation came, however, in the content of the existing jobs. As with the folding machines, the gathering machines require workers to set up and monitor the operation, rather than to directly operate them.

These operators continued their employment as gathering-machine setup men. The displacement of fillers-in, and the acquisition of gathering-machine feeders represent a somewhat similar situation, i.e., no actual displacement occurred, although there was minimal change in job content.

The installation of casing-in-line equipment eliminated the following jobs in the banding and line department and the rounding, backing and casing-in-line departments: Head-bander-and-liner operator; back liner; rounding-and-backing-machine operator; rounder; backer; caser; and presser. This displacement, however, was partially offset by the new jobs created, that of casing-in-line setup man, and casing-in-line feeder.

The installation of casing-in-line equipment eliminated the individual operations performed by these workers. The rounding of the backs of book bodies, the forming of joints at the back edge of rounded book bodies, the gluing of headbands, supers, and linings to backs of book bodies, the attaching of cases to book bodies, and the pressing of cases to book bodies are all accomplished in sequence in a continuous operation by a series of automatic machines. Workers who were transferred to the casing-in-line setup man jobs were those with previous experience in setting up bindery machines which are obsolete following the installation of the casing-in-line equipment. Skills possessed by these workers were utilizable in the casing-in-line setup man jobs, although some on-the-job training was necessary. Displaced workers were also transferred to the casing-in-line feeder jobs, and also received on-the-job training of short duration.

PLANT II

This plant has introduced the perfect-binder process into its bindery operations for production of paperbound books. This process produces paperbound books in a continuous operation which includes the gathering of folded signatures, the gluing and stitching (stapling) of signatures into book bodies, and the gluing of the book bodies into covers. The number of workers employed in the stitching department decreased after the installation of perfect-binder equipment. The hand operations of stitching were eliminated, thereby displacing hand stitchers. Wire-stitcher feeders, side-stitching-machine signature-feeders, and side-stitching-machine receivers also were displaced. A partial offsetting of this displacement resulted from the need for stitching-machine feeders, and perfect-binder feeders. The elimination of the side-stitching-machine operator job displaced some employees, but the perfect-binder operation created the need for perfect-binder setup men.

The jobs in the new process were filled by workers with previous bindery experience, primarily those who were displaced by the automated operations. These workers were able to utilize similar skills acquired from previous experience. In most cases the workers needed only limited on-the-job training. The casing-in-line feeder jobs and the perfect-binder feeder jobs were filled by workers with previous experience in hand operations, feeding or offbearing, or material handling. The casing-in-line setup man jobs and the perfect-binder setup man jobs were filled by workers who previously set up and operated single-function machines.

Case Study of Changes in Composing Room and Bindery Processes

A case study of changes in composing room and bindery processes was made of specific occupational changes brought about in composing room and bindery processes as a result of the introduction of automated equipment. Typesetting and binding, the two processes chosen for inclusion in this study, were studied from the viewpoint respectively of: (1) What happens when automatic linecasting or filmsetting equipment is introduced into a traditional composing room setting; and (2) what happens when highly automated equipment—multiple-function machines or continuous workflow systems—is introduced into bindery operations employing single-function, some multiple-function machines, and hand operations?

The data were gathered in six composing rooms and two binderies, all in a single geographical locality. Each of these plants had installed new equipment which to some extent modified the workflow systems and occupational structures.

TECHNOLOGICAL CHANGES IN COMPOSING ROOM PROCESSES

To prepare a manuscript copy for printing, a number of processes must be undertaken. The initial process in this preparation is typesetting, with which this part of the study is concerned. Typesetting is the process of setting the manuscript copy of the materials to be printed in metal type or film. These processes are carried out in a composing room where the manuscript copy is read and set in metal type or exposed on film, chiefly by use of machines (machine composition), but also by hand (hand composition). The set type or exposed film undergoes further processing to prepare it for the actual printing operation.

Automatic Linecasting [4]

With the introduction of a device called a Teletypesetter into the composing process, it became possible to operate linecasting machines (Linotype and Intertype) automatically. This device alters hot-metal composition, using linecasting machines, into a two-step operation: (1) Tape perforating and (2) machine composing. The keyboard operator of the perforator records, by means of perforations, every letter, character, and composing function on tape, which then is transferred to the composing machine. The tape is then fed into the unit which "senses" the code perforations in the tape and automatically activates the composing machine.

Resulting Workflow

As contrasted to the steps involved in typesetting using traditional typesetting equipment, two changes are apparent. In the tape-perforating operation, an additional job, that of typesetter-perforator-machine operator, is needed to produce tape for the automatic linecasting operation. Instead of Linotype (or Intertype) operators the job typesetting-machine tender appears, which replaces three of four individual machine operators. The perforated tape fed to the modified Linotype (or Intertype) machines automatically controls the operations to affect the composing function. One typesetting-machine tender can monitor three to four linecasting machines so equipped. The subsequent operations in the typesetting process remain essentially the same. No additional jobs are required, although, numerically, the number of personnel assigned to each job could increase as production increases. Automatic linecasting provides for a higher speed of operation, therefore a greater output, than is otherwise possible on linecasting machines because of the limitations of the individual operator.

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[4] Also referred to as teletypesetting, a word used to describe any system providing for remote transmission of data, as well as specifically, automatic operation of linecasting machines.

To produce a preforated tape, the typesetter-perforator-machine operator, reading from manuscript copy, operates a keyboard similar in arrangement to a typewriter. As he presses the keys, the letters, characters and composing machine functions are recorded by perforations in a paper tape. On completion, he removes the tape for delivery to the typesetting machines.

To set type, the typesetting-machine tender inserts the perforated tape in the tape converter attached to a linecasting machine. He then starts the unit that controls the typesetting operation of the linecasting machine by means of the coded signals on the perforated tape. During the automatic typesetting operation, the tender monitors the machine.

Implications of Automatic Linecasting

The installation of automatic linecasting equipment at the plants studied resulted in: (1) The displacement of workers functioning as Linotype (or Intertype) operators and machinists, (2) the substitution of less complex jobs, that of typesetter-perforator-machine operator and typesetting-machine tender, and (3) when production rises, an increase in the number of workers employed in select classifications, such as proofreaders.

Filmsetting[5]

The development of composing machines employing a photographic process (filmsetting) rather than the heretofore hot-metal process marked a significant technological revolution in the history of composition. The "hot-metal" principle in machine construction which has prevailed since the time of its introduction was abandoned, and a photographic principle substituted. Filmsetting machines, however, embodied the principles of the keyboard and the use of a storage compartment, containing film and two dimensional representations (referred to also as matrices or mats) of letters, numbers, and other characters as contrasted to the three-dimensional matrices used in hot-metal machines. Similar to the one- or two-step hot-metal composing machines, these machines provide for either direct keyboard operation (phototypesetting machines), tape-controlled operation (photocomposing machines), or manual positioning (photolettering machines).[6]

There are numerous systems of photographic composition and the machines and methods employed vary from desk or table-top models to complex floor mechanisms. The desk or table-top models are primarily manually operated and used for headlines and display work (photolettering machines). The floor machines, which may employ electronic systems, computer systems, and optical systems, can be used for body matter or straight matter as well as headlines and display work (phototypesetting and photocomposing machines).

Filmsetting Machines

Phototypesetting Machines.—To prepare film, the phototypesetter operator, reading from the manuscript copy, operates the keyboard of an automatic machine to photographically print type matter onto strips of photosensitive paper. In this way, paper flats are prepared for making printing plates. As he depresses the keys, the individual matrices or mats, containing small film negatives, are assembled and photographed in the machine as a line of type on film.

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[5] Composition using a photographic process is also referred to as phototypography, photosetting, phototypesetting, or photocomposition. The word "filmsetting" has been arbitrarily selected for use here.

[6] This division of phototypesetting machines, photocomposing machines, and photolettering machines represents an arbitrary breakdown of filmsetting machines.

Photocomposing Machines.—Composition using photocomposing machines is a two-step operation. A separate keyboard is employed to perforate a tape which is then fed into a photographic unit to effect composition. To produce a perforated tape, the photocomposing-machine-perforator operator, reading from the manuscript copy, operates a keyboard. As he depresses the keys, a magnetic tape or a perforated paper tape, encoded with instruction for the photocomposing machine, is produced. The tape is fed to the photocomposing machine to prepare film, the photocomposing-machine operator inserts the tape into the photographic unit. He then monitors and adjusts the machine which "reads" the tape and automatically actuates the character-selecting mechanism and photographs the individual character contained in the machine, according to the coded signals on the tape.

Photolettering Machines.—Lettering using a photolettering machine is a two-step operation, involving: (1) Manually positioning the mat of each character for exposure; and (2) composing by machine. To prepare film, the photolettering-machine operator, reading from the manuscript copy, inserts specified film fonts in the machine reel. The operator turns the reel to a specified selector mark to position the letters to be printed. He tends the photolettering machine while it photographically prints on film or photopaper.

Workflow in Filmsetting

Filmsetting and perforator-machine operators set up their machines according to the instructions contained in the manuscript copy, to compose on film or prepare tape. The photocomposing-machine-perforator operator copies the data from his portion of the manuscript onto tape for use in the photocomposing machine. The photocomposing-machine operator inserts the perforated tape into the photocomposing machine to effect composition. The phototypesetter operator, reading from his assigned portion of the manuscript copy, operates the keyboard of the phototypesetting machine to prepare paper flats for making printing plates, and the photolettering-machine operator composes letters in film for headlines and advertising. Following the photographic composition, a transparent negative or positive is developed. A Xerox, blueprint, vandyke, Ozalid or autopositive is made for proofreading. The proof is read and marked for correction of errors. A corrected negative or positive is prepared, according to the proofed copy, and the pages are made up. If a film negative has not been produced in the initial developing step, the page makeup is photographed to make offset negatives. The negatives are then arranged on a light table to make flats which are used to prepare an offset plate.

Implications of Filmsetting

Photographic composition is not a substitute for metal type but rather an entirely new method of typesetting and makeup. Most photographic composing equipment has been designed as similar as possible in appearance and operation to its hot-metal counterparts, thus utilizing the skills acquired by workers in the industry and minimizing the retraining program. For instance, Linotype (or Intertype) operators can operate keyboards of phototypesetting machines with little retraining. The differences in the function involved are accomplished by the machine rather than by the operator. However, some photographic composing equipment, used for special or unusual printing runs, is quite different in appearance and operation from conventional equipment.

Filmsetting equipment may, however, require the operator to have both typesetting and photographic skills. In addition to operating the machine, he may be required to perform darkroom work to develop the exposed film, and may also have to assemble and arrange the developed film into pages. Further, some filmsetting machines may employ electronic systems. The operator, if making minor repairs on these machines, would have to have a basic working knowledge of the principles of electronics.

TECHNOLOGICAL CHANGES IN BINDERY PROCESSES

Two plants in the printing and publishing industry were studied to investigate changes that have occurred in bindery operations because of the use or application of automated equipment. The first plant studied represents the bindery and finishing operations of a firm that prints and publishes such products as annual reports, books, business directories, catalogs, maps, tickets, travel literature, and visual aids. The second plant studied represents the bindery and finishing operations of a firm that prints and publishes such products as annual reports, children's books, textbooks, magazines, comics, games, and toys. Both plants have installed the latest in automatic equipment for their bindery operations.

Trends in Bindery Processes

Paralleling the rapid increase of printing production and the technological advances made within other processes of the graphic arts, have been many developments and improvements in bindery and finishing. Many unusual and unique applications of binding equipment and methods have been developed to serve special and high-volume needs in the finishing operations.

Until recently bindery operations were done primarily by hand and with single-function machines. Hand operations were replaced with single-function machines and these in turn with multiple-function machines and continuous workflow systems. With the invention of conveyor feeders incorporating a simple mechanical timing device, it became possible to link together many bookbinding machines into an automatic line.

Now automatic folding machines have eliminated the tedious handfolding operations. Continuous casing-in-line operations have replaced operations previously done by hand or by single-function machines, such as the operations of serving, smashing, trimming, gluing, rounding and backing, triple lining, casing-in, pressing, jacketing, and packaging, without intermediate handling. The perfect-binding process makes paperbound books by a continuous operation which replaces the stitching operations.

Cutting

Cutting is one of the less complex operations in the finishing and binding process. Although improvements have been made in this operation, no significant impact on job duties has resulted. Hand- and power-operated back gauges have been replaced by automatic spacing mechanisms. Reduced machine maintenance and increased operating safety have resulted from the use of more functionally designed cutting equipment, machined more accurately from materials better suited for the cutting operations. In addition, special safety devices on cutters are commonly used today.

Trimming

Significant progress has been made in improving trimming operations. Recent developments include accurate, high-speed trimmers which operate with as many as five knives rather than the previous single-knife operation. These trimmers are capable of trimming two or three books at a time—an improvement over the single-book trimmer.

Folding

A significant advancement in folding has been the design and construction of high-speed rotary folders attached to web-fed presses. The presses produce printed and folded signatures. Another advancement has been the development of equipment to eliminate the hand operation required in connection with special folds sometimes desired on books and magazines. Modern folders are being designed for maximum production. In developing new folding machinery, the stress has been placed on accuracy, flexibility, and simplicity of changeover, as well as on speed. In the folding department, the folding-machine setup man sets up machines that automatically fold and cut printed sheets into signatures for binding. The folding-machine feeder feeds the printed sheets into the fold guide of the machine.

Sewing

Although machines have been developed which operate with automatic feeders to increase production, book sewing still remains a relatively slow and costly operation. For this reason many efforts have been made to eliminate sewing. So far, the success achieved has been in the use of special adhesives which adhere to the individual sheets of a book and bind them together as a unit.

Casemaking

Casing-in, the process of putting book bodies into covers, has been significantly changed by technological developments. Many producers have created combinations of machine operations to make virtually a continuous operation of bindery processes such as rounding and backing, supering and lining, casing-in and building-in. This search for combined operations has resulted in continuous workflow systems. Such systems eliminate much of the individual handling of the materials and save substantial amounts of inprocess storage space. The gathering-machine setup man sets up, according to blueprint specifications, machines that automatically gather signatures and form book bodies for binding. The gathering-machine feeder feeds signatures into the machine. The casing-in-line setup man sets up, according to blueprint specifications, machines that automatically perform in sequence such operations as rounding and backing, supering and lining, casing-in, and pressing to convert gathered signatures into finished book. The casing-in-line feeder feeds gathered signatures into the machine.

Perfect Binding

The perfect-binding process is another example of utilizing continuous workflow systems to achieve multiple operations. This process produces paperbound books by a continuous operation. The perfect-binder setup man sets up, according to blueprint specifications, a machine that automatically gathers and stitches signatures into book bodies and glues them into covers to form paperbound books. The perfect-binder feeder feeds signatures and book covers into the machine.

Perfect binding has become a widely used form of binding primarily because of the development of permanently flexible adhesives. Virtually all large catalogs, directories, and similar thick, inexpensive publications are perfect bound. Many of the mass-produced trade books and widely distributed publications also are bound by this process.

Hand Binding

Some books are still bound by hand. Hand binders deal with binding of single copies which cannot be done economically by machine. They repair rare books, make fine-tooled bindings, and bind reference books and books of special value.

APPENDIX II

SIGNIFICANT NEW JOB AREAS

Item 1

HEALTH PHYSICIST.—Devises and directs research, training, and monitoring programs to protect plant and laboratory personnel from radiation hazards: Conducts research to develop inspection standards, radiation exposure limits for personnel, safe work methods, and decontamination procedures, and tests surrounding areas to insure that radiation is not in excess of permissible standards. Designs or modifies such health physics equipment as detectors and counters to improve radiation protection. Assists in developing standards of permissible concentrations of radioisotopes in liquids and gases. Directs testing and monitoring of equipment and recording of personnel and plant area radiation exposure data. Requests bioassay samples from individuals believed to be exposed. Consults with scientific personnel regarding new experiments to determine that equipment or plant design conforms to health physics standards for protection of personnel. Supervises radiation monitoring personnel and directs monitoring of plant areas and worksites. Requisitions and maintains inventory of instruments. Records location and quantity of radioactive sources assigned to departments. Instructs personnel in principles and regulations related to radiation hazards. Assigns film badges and dosimeters to personnel, and recommends changes in assignment for health reasons. May advise public authorities on methods of dealing with radiation hazards, and procedures to be followed in radiation incidents, and assists in civil defense planning.

Item 2

OPTICAL-MISSILE-TRACKING TECHNICIAN.— Sets up equipment and tracks missiles on downrange flights, using photo-optical instrumentation devices and procedures: Sets up photographic and related telemetering and tracking equipment according to formalized procedures, maintenance manuals, and schematic diagrams. Makes adjustments based on current conditions and familiarity with photogrammetry and astronomy photographic optics, using handtools and test equipment. Operates equipment during missile launching to register position, trajectory, flight altitude and other data concerning missile behavior for analysis by engineering and scientific personnel. May install, calibrate, and adjust optical and photographic data-collection equipment in missile, aircraft, or underwater equipment instrument package, taking into consideration such factors as changes in pressure, temperature, and available light. May evaluate adequacy of data obtained to determine need for future changes in instrumentation. May modify existing equipment and participate in planning and testing modified equipment and instrumentation procedures for special ordnance applications, such as rocket sleds, experimental aircraft, and weaponry.

Item 3

NUCLEAR MEDICAL TECHNOLOGIST.—Prepares, administers, and measures radioactive isotopes in therapeutic, diagnostic, and tracer studies, utilizing a variety of radioisotope equipment: Prepares stock solutions of radioactive materials, and calculates doses to be administered by RADIOLOGIST. Measures glandular activity, traces radioactive doses and calculates amount of radiation, using equipment such as Geiger counters, electroscopes, scalers, scintillation and positron scanners, and scintigrams. Calibrates equipment. Subjects patients to radiation and X-ray therapy, as prescribed by RADIOLOGIST, using such equipment as radium emanation tubes and needles, X-ray machines, and similar instruments. Executes blood volume, red-cell survival, and fat-absorption studies, following standard laboratory techniques.

Item 4

SYSTEMS ANALYST.—Analyzes data-processing problems to devise computer system requirements, to plan machine layout, and to develop programing procedures: Confers with other technical personnel to determine problem and type of data to be processed. Analyzes problem in terms of equipment capability to determine techniques and formulate computer system requirements most feasible for processing data. Prepares definition of problem together with recommendations for equipment needed for its solution, from which PROGRAMER, ENGINEERING and SCIENTIFIC prepares flow charts and computer instructions. Directs and coordinates installation of computers system. Devises data verification methods, and establishes standards for preparation of operating instructions. May schedule data-processing activities. May supervise preparation of programs.

Item 5

MECHANICAL-ENGINEERING TECHNICIAN.—Applies theory and principles of mechanical engineering to develop and test machinery and equipment under direction of engineering staff and physical scientists: Reviews project instructions and blueprints to determine test specifications, procedures, objectives, test equipment, problems involved and possible solutions, such as if parts must be redesigned, material or parts changed, or parts or subassemblies rearranged. Prepares detailed drawings or sketches to scale for drafting room or when requesting fabrication by machines, wood, or sheet-metal shops. Develops, fabricates, and assembles new or modified mechanical components or assemblies for machinery and equipment, such as industrial equipment and machinery, power equipment, servosystems, machine tools, and measuring instruments. Sets up and conducts tests and experiments of complete units and components to investigate engineering theories regarding improvement in design or performance of equipment, to subject equipment to simulated operating conditions, and for such purposes as development, standardization, and quality control. Analyzes indicated and calculated test results against design or rated specifications and objectives or tests, and modifies equipment to meet specifications. Records test procedures, results, and suggestions for improvement. Prepares engineering drawings, charts, and graphs.

Item 6

SECTION CHIEF, AUTOMATED PROCESSES.—Plans, directs, and coordinates the installation, modification, and operation of automated production line to produce deposited carbon resistors for use in electronic equipment, such as missile control systems: Collaborates with engineering associates to design and modify machines and electronic equipment to produce resistors within specified manufacturing tolerances. Devises data verification and quality-control methods and establishes operating standards. Schedules workflow, develops programing techniques, and converts production data into machine language using code manuals. Issues program and electronic setup data to ELECTRONIC TECHNICIAN, AUTOMATED PROCESS, mechanical setup data to MACHINIST, AUTOMATED PROCESS, and quantity and size of resistor parts to be fed into machines to UTILITY OPERATOR, AUTOMATED PROCESS. Verifies setup of automated line against setup instructions. Interprets feedback data, graphs, and instrument readings to detect malfunctions in mechanical and electronic equipment. Guides and supervises subordinates in analyzing electronic circuits and/or mechanical units following schematic and wire diagrams and/or blueprints and tolerance charts. Directs adjustment, repair, replacement, or modification of components along automated line to restore production and/or increase operating efficiency. Compiles records, charts, and reports concerning production, machine efficiency, and maintenance time. Inventories and requisitions supplies and equipment. Trains new workers.

Item 7

CONVEYOR-LINE OPERATOR, AUTOMATIC.—Operates console that controls automatic palletizing equipment to sort, transfer, and stack on pallets containers of finished products, such as sugar and cigarettes: Reads production and delivery schedules and stacking pattern to determine sorting and transfer procedures, arrangement of packages on pallet, and destination of loaded pallet. Observes packages moving along conveyor to identify packages and to detect defective packaging, and presses console buttons to deflect packages to predetermined accumulator or reject lines. Turns selector switch on palletizer to control stacking arrangement of packages on pallet and to transfer loaded pallet to storage or delivery platform. Supplies loading equipment with empty pallets. Stops equipment to clear jams. Informs repairman of equipment malfunction. May keep record of production and equipment performance.

Item 8

CONTROL MAN.—Operates control panel to regulate temperature, pressure, rate of flow, and tank level in petroleum refining, processing, and treating units and petrochemical units, according to process schedules: Observes instruments and meters to verify specified conditions and records readings. Moves and adjusts dials, switches, valves, and levers on control panel to regulate and coordinate process variables, such as flows, temperatures, pressures, vacuum, time, catalyst, and chemicals as specified. Reports malfunctioning equipment. Records results of laboratory analysis. May test products for chemical characteristics and color, or send them to laboratory for analysis. May change recording charts and ink pens. May operate auxiliary equipment to assist in distilling or treating operations. May lubricate equipment.

Item 9

STEAM PLANT OPERATOR.—Controls the generation of electric power in a steam electric generating plant of a power utility from a central control unit: Reads lighting-off orders to determine auxiliary equipment, cooling and lubricating oil systems, and hydrogen-gas system scheduled to be operated. Directs personnel working outside of control room to line up specified machinery and equipment. Checks off equipment on master check sheet as it is reported ready for operation. Turns automatic remote controls to light-off boilers and start auxiliary equipment such as man-feed pumps, fuel pumps, air compressors, and water treatment equipment. Sets controls on panelboard to maintain specified pressures and temperatures of equipment according to lighting-off orders during warming-up operations. Starts transformers and energizes switching gear preparatory to putting plant in power system. Synchronizes phasing, frequency, and voltage of plant equipment with system, and when directed by personnel at load dispatching station, throws switch to put power generated into system. Observes tell-tale systems and closed television circuit to detect malfunctions of equipment. Adjusts controls to obtain specified performance of equipment and maintain power load specified by load-dispatching personnel. Issues work clearances for tests, repairs, and maintenance on auxiliary machinery and equipment. Attaches tags on panelboard controls when equipment is being worked upon to prevent accidents. Enters time of removal of equipment from standby status in log. Records operating data, such as load conditions, switching operations, and equipment failures in log. Reads meters and enters readings on forms. Changes charts on automatic recording instruments daily.

Item 10

PROGRAMER, ENGINEERING AND SCIENTIFIC.—Converts or directs conversion of symbolic statements of scientific or technical problems into diagrams and language for solution by means of automatic data-processing equipment: Analyzes statement of problem as prepared by COMPUTING ANALYST, applying knowledge of subject matter involved and of symbolic logic. Confers with managerial and technical personnel to facilitate analysis. Breaks down statement of problem into steps for solution. Designs detailed programs, flow charts, and diagrams indicating sequence of machine operations necessary to carry out compilation and computation of data to solve problem. Translates or directs translations of mathematical formulas into language that can be understood by specified computer. Verifies accuracy and completeness of program by preparing sample data and testing data on computer by operating console. Prepares instruction sheet to guide CONSOLE OPERATOR during production run. Corrects program errors by revising instructions or altering sequence of operations. Evaluates use of canned (standardized) programs in solving routine problems and modifies such programs when necessary.

Item 11

CONSOLE OPERATOR.—Monitors and controls electronic computer that processes data to maintain business records or to solve scientific, engineering, or other mathematical problems by interpreting programing instructions and operating central control unit known as console: Studies program instruction sheet to determine equipment setup and operating instructions. Mounts reels of tape in sensing units that extract input data or record output data. Switches auxiliary equipment, such as automatic typewriter and peripheral machines, into circuit to close loop and effect feedback of data. Moves control switches on console panel to start and adjust electronic computer that reads and processes data. Observes console lights, tape units, and action of automatic typewriter to monitor system and detect malfunctions. Tears printed sheets from typewriter at designated points for verification of processed data against program. Reports machine malfunctioning. Moves controls, according to standard procedures, to rearrange sequence of program steps in order to correct computational errors or to continue operations when individual units of system malfunction. Rewinds and removes tape at completion of processing. Maintains operating records, such as machine performance, operating time, and production reports.

Item 12

TOOL PROGRAMER, NUMERICAL CONTROL.—Plans program to control machining of metal parts by automatic machine tools utilizing magnetic tape, punched tape, and punched cards: Analyzes blueprints and engineering drawings to determine dimension of parts and configuration of cuts. Determines position of metal stock on machine fixture and point on stock at which machining should start. Draws sketches of part to plan number, location, and direction of cutter paths. Establishes location of tool set point, starting point, and cutter change points by three-dimensional coordinates, according to reference point and location of stock on fixture, and plots cutter center paths on graph paper. Calculates radii of simple and complex irregular curves, using square root calculator. Prepares program sheet for direction of KEY-PUNCH OPERATORS in transcribing data onto punchcards and magnetic- or punched-tape controls, including step-by-step directions for movement of machine cutter from change point to change point in three-dimensional coordinates and data such as feed rate, cutter speed and direction in symbolic language. Verifies punchcards and magnetic or punched tapes with written plans for accuracy. Observes machining of first part produced by automatically controlled machine to verify accuracy of programing. May determine suitability of part for machining by automatic machines.

Item 13

DRILL-PRESS OPERATOR, TAPE CONTROL.—Sets up and operates tape-controlled, turret-type drill press that automatically positions indexing table, selects tools, and drills, reams, and taps metal castings: Installs holding fixture on indexing table of machine and control tape in reader at zero point indicated on process diagram. Locks drilling, ream-ing, and tapping tools in turret in sequence specified on process sheet. Positions casting in holding fixture and starts machine to perform trial run. Stops machine at each tool and table position during trial run and verifies diameter and depth of cut, using specified fixed gauges. Turns screw on turret indexing head to adjust depth of cut. Notifies supervisor when hole diameters do not conform to specifications. Positions new casting in fixture and starts machine which automatically positions indexing table, selects tools, and machines casting through predetermined code punched in control tape. Verifies dimensions of holes, using fixed gauges and following diagram of casting.

Item 14

FARM-EQUIPMENT MECHANIC.—Maintains, repairs, and overhauls farm machinery, equipment, and vehicles, such as tractors, harvesters, pumps, tilling equipment, trucks, and other mechanized, electrically-powered, or motor-driven equipment on farms or in farm-equipment repair shops: Examines machines, motors, gasoline, and diesel engines, and equipment, visually and aurally, for operational defects and dismantles defective units, using handtools. Repairs or replaces defective parts, using handtools and machine tools, such as drill press, lathe, milling machine, woodworking machines, welding equipment, grinders, and saws. Reassembles, adjusts, and lubricates machines and equipment to insure efficient operation. May install and repair wiring and motors to maintain farm electrical system. May install and repair farm plumbing systems. May construct and repair buildings and other farm structures. May assemble and erect new farm machinery and equipment.

Item 15

FARM-EQUIPMENT OPERATOR.—Drives and controls farm equipment to till soil and to plant, cultivate, and harvest crops: Hitches soil-conditioning implement to tractor and operates tractor and towed implement to furrow and grade soil. Drives tractor and operates designated towed equipment to plant, fertilize, dust, and spray crops. Prepares harvesting machine by adjusting speeds of cutters, blowers, and conveyors and height of cutting head or depth of digging blades according to type, height, weight, and condition of crop being harvested, and contour of terrain. Attaches towed- or mounted-type harvesting machine to tractor, using handtools, or drives harvesting machine to cut, pull up, dig, thresh, clean, chop, bag, or bundle crops. May drive team to pull farm equipment.

Item 16

PRINTED-CIRCUIT TECHNICIAN.—Fabricates printed-circuit boards used as prototypes of production models, following blueprints, sketches and using photoengraving equipment, handtools, and soldering iron: Lays out circuit pattern on paper with tape, or draws pattern with pen and ink, to prepare master drawing. Photographs pattern and prepares negative for photoengraving process. Places negative on copper-faced laminated plastic board in contact printer to expose acid-resistant enamel on surface of board. Etches board to form circuitry. Cuts board to specified dimensions, using router. Drills component holes in board, using drill press. Installs hardware, such as brackets, eyelets, and terminals to boards. May operate silk-screen printing machine to apply acid-resist to circuit boards.

Item 17

ETCHED-CIRCUIT PROCESSOR.—Prints and etches conductive patterns on copper-faced plastic boards to produce printed-circuit boards, using photoengraving and etching equipment: Immerses board in cleaning and degreasing solution. Sprays light-sensitive enamel on copper surface of board, or brushes enamel on board and places board in machine (whirler) that spins board and spreads enamel over board surface. Positions board and circuit negative in contact printer and exposes board to arc light for specified period of time to transfer image of circuit to board. Immerses exposed board in solution to develop acid-resistant circuit pattern on board surface.

Examines board to verify development of pattern and brushes acid-resist over sections of pattern not developed. Immerses board in acid, or tends etching machine to etch conductive pattern in copper surface. Immerses board in solutions to dissolve enamel. May apply heat to developed areas to burn-in developed image, using torch or Bunsen burner. May use silk-screen printing machine to apply acid-resist to circuit boards.

Item 18

COMPONENT-INSERTING-MACHINE OPERATOR.—Tends machine that installs electron components, such as resistors, capacitors, and diodes, on printed-circuit boards: Loads components in feeding mechanism of machine. Positions printed-circuit board on bed of machine under inserting tool. Pushes pedal to lower tool that bends component's lead wires and inserts lead wires into holes in board. Places board on conveyor or in receptacle for soldering operations.

Item 19

CONTROL-BOARD OPERATOR.—Sets up and operates batching plant electronic console to control the measuring and mixing of ingredients to produce concrete according to customers' specifications: Calculates weights of proportions of mix from order. Presets specified mix weights on selective controls of console by turning setscrews, or punching out mix formula on punchcard and inserting it in slot in console. Starts automatic operation of console by flipping a toggle switch. Observes meters and dials to verify the accuracy and consistency of mix. Mixes custom, or odd size, batches of concrete by pushing button controls. Adjusts dial that controls water input to compensate for moist aggregate. May act as dispatcher for mixer trucks. May take customers' orders on the phone.

Item 20

PEELING-MACHINE OPERATOR.—Sets up and operates peeling machine to head and peel shrimp preparatory to canning or freezing: Spaces peeling rolls on machine according to size of shrimp to be processed, and adjusts holding rack bars to intermesh between rolls, using wrenches. Turns thumbscrews to adjust spring tension on holding-rack bars according to shrimp size, and turns valves to start waterflow over rolls. Starts machine and feed conveyor, and spreads shrimp over feed pan at head of rolls to insure even distribution, using wooden rake. Examines random samples of shrimp at discharge end of machine to ascertain relative efficiency of peeling and heading operation, and adjusts roll spacing and holding-bar tension accordingly. Dismantles and cleans machine with high-pressure stream from water hose. May sterilize machine parts by directing hot water or live steam over them with hose.

Item 21

SORTER OPERATOR, MACHINE.—Operates magnastat memory-controlled equipment to sort and rack lumber according to thickness and moisture content: Scans each board as it passes on green chain to determine thickness and lifts end of each board to determine moisture content by weight. Depresses appropriate button on control panel to route each piece of lumber onto specified conveyor-holding rack.

Item 22

CUT-OFF SAWYER.—Operates circular saw and conveyor system activated by panel buttons and foot controls to cut logs to specified, usable, or economical lengths: Starts saw and conveyor belts and presses foot pedal to transfer log to feed conveyor, using kicker arms. Observes log to ascertain economical or usable size and presses button on panelboard to lower saw to trim and square log ends and cut log. Cuts log to specified length by pressing button to register length specification on control panel which automatically measures log and lowers saw to cut log when log reaches selected position. Controls discharge conveyor to transfer log to head-saw operator or gang sawyer according to size and texture of log, or distributes load evenly when working with uniform logs.

Item 23

TIPPLE MAN.—Operates tipple chain conveyor to move presorted lumber from holding racks to stacking platform according to orders received by intercommunication system or hand signal: Depresses control buttons to raise, lower, and align tipple with holding racks which hold lumber requested. Pulls levers to release stops at ends of holding racks, allowing lumber to move down to tipple conveyor chain which transfers lumber to stacking platform. Straightens lumber as it moves on conveyor to prevent or remove jams.

THE LABOR FORCE ADJUSTMENT OF WORKERS AFFECTED BY TECHNOLOGICAL CHANGE

Robert C. Goodwin

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THE DEVELOPMENT OF AN integrated manpower policy and program was not a serious subject of national concern in the United States, except during emergency periods of war or depression, until the turn of the present decade. Many pieces of legislation have had deep and enduring effects on the preparation and utilization of our manpower resources—from immigration laws and Federal support of land-grant colleges and vocational education to child labor regulation and social insurance—but these were primarily designed to meet specific social or economic problems. Even the establishment of the U.S. Employment Service in 1933 and the creation of a Federal-State unemployment insurance system in 1935 were responses to the exigencies of the mass unemployment of the great depression.

For many years, we have largely taken our labor supply for granted. It was assumed—and with a solid basis in experience—that as industry and jobs developed, the needed manpower would come, across the country or half way around the world, if need be. And, sometimes through formalized training, more often by trial and error, workers found jobs and developed the needed skills.

Since the end of World War II, however, the United States has been undergoing a gigantic industrial transformation, reflecting a very rapid increase in population, economic growth, the introduction of important new production techniques and processes, and widespread geographic shifts in industry location. The full force of the industrial revolution has come to agriculture, and the resulting increases in productivity have accelerated the movement of population from rural to urban areas. None of these forces of change and progress is entirely new to our experience. What is new is the rate at which these changes are taking place, the magnitude of the resulting problems, and the lack of already-developed institutions, practices, and legislation to deal effectively with the impact of these changes.

The swift pace of change requires rapid and sensitive adjustments of the labor force to prevent or minimize serious personal and social dislocations. The mobility and flexibility of the American labor force are almost legendary, but by themselves they are not enough to keep abreast of the new forces that continuously upset the equilibrium between manpower supply and demand. We have only recently begun to see and to take steps to develop imaginative ways to facilitate manpower adjustments and to adapt our institutional framework to meet the complex new problems.

I should like to emphasize that we in the United States are only at the beginning of a new era in manpower development and use. The new problems are too difficult and too interrelated to permit simple solutions. But we have come to a full recognition of the need for an active manpower policy, we have defined the basic elements of such a policy, and we are experimenting with a variety of approaches to implement our purposes. Within the past 3 years we have seen congressional enactment of the Area Redevelopment Act, the Public Works Acceleration Act, the Manpower Development and Training Act, the Trade Expansion Act, the Vocational Education Act of 1963, and most recently the Economic Opportunity Act.

In each of these there is specific concern with a manpower problem or problem area—with the development of job opportunities where they are lacking, or with the provision of training or education to enhance or promote employability of workers. In all of them the U.S. Department of Labor, its Bureau of Employment Security, the U.S. Employment Service, and the affiliated public employment services of the 50 States, have a major manpower role.

In relation to the topic of this discussion, "The Adjustment Process of Individuals," this role is to work toward an efficient relationship between fluid and changing manpower demands in a free job market, and a labor supply of essentially self-determining individuals. For workers affected by technological change, this involves individuals who are trying, sometimes desperately, and sometimes with overtones of defeat, to meet the demands of that market. Stated in terms of some of the problems involved, the U.S. Department of Labor and its affiliated State agencies attempt to utilize the tools afforded by the Congress to deal positively with such areas of dislocation as persistent unemployment, large simultaneous layoffs of workers, and the unemployed workers' ability to cope with adjustment problems. These include problems resulting from technological change and those experienced by young people trying to find a way successfully into the job world for the first time.

There are two assumptions basic to this attempt, which contribute importantly to its character and direction. One is that the local job market is a major dimension of the manpower and employment problem in this country. There is much incontrovertible evidence of high labor mobility in the facts that the average American worker holds about six different jobs in his lifetime; very few workers are in the jobs for which they were first trained; and the unemployed coal miner in the East somehow packs up and goes out to the copper mines of the West. While there is certainly no neglect of the national dimension of the American manpower problems, it appears to be operationally practical and necessary to speak, for example, of the impact of automation on Detroit, Mich., or Omaha, Nebr.

A second assumption is that measures to promote a high level of effective demand through fiscal and monetary policy, and those to increase the efficiency of local job markets go hand in hand, and that they are not necessarily alternative approaches. It is of little comfort to a meat packing-house worker out of a job because of a plant closing in Sioux City, Iowa, to know that building construction workers are in demand in Baltimore, Md., because of a boom in apartment house construction. It is likewise of little practical significance to the public employment service people who are trying to find him a new job. Thus, the immediate adjustment problem exists in the local community, at the level of the individual plant, job, and worker. It is consequently in these terms that much of our national manpower planning comes into operation.

To illustrate the operational characteristics, this discussion will describe several programs that are part of our national response to the problem implicit in the specific topic, "The Labor Force Adjustment of Workers Affected by Technological Change." The first of these is what is generally called "Automation Pilot Projects."

AUTOMATION PILOT PROJECTS

In late 1961, the U.S. Employment Service initiated a special inquiry into the impact of technological change on the labor force and its implications for operations of the public employment service. This special inquiry has involved 24 automation pilot projects conducted by 14 of the affiliated State employment services. The purpose of the projects is to obtain generalizable experience and insights into local employment and unemployment problems associated with technological change, and to experiment with services to workers and employers while taking action on the problems.

Project activities have included inplant analyses of job changes; intensive counseling, testing and placement services to displaced workers; and documentation of worker characteristics, adjustment services offered, and post-layoff employment experience of displaced workers.

Six projects primarily involve displaced workers, six are concerned with inplant effects of automation, and six projects include both inplant effects and displaced workers. In addition, two projects concentrate on special problems of the long-term unemployed and four projects are industry studies.

Although the projects are in various stages of completion and much of the information has not been subjected to rigorous analysis, some preliminary impressions can be stated about employment problems associated with automation and technological change.

1. The first and most obvious observation, of course, is that at the individual establishment level the introduction of automated processes or technological improvements reduced the amount of labor input required per unit of product.[1] Many employers avoided layoffs by reducing staff through attrition, and by transferring affected employees to other jobs within the establishment. Regardless of what measurement was used, however, less labor was required. The reduction in labor input took a number of forms:[2]

    a. Outright layoffs of workers.

    b. Increase in output without a corresponding increase in the work force.

    c. Reductions in new hires.

    d. Shortened workyear, reduced use of overtime or of subcontractors.

It should be noted that these forms of reduction in labor input have been found in a variety of case-study circumstances, and it appears that any one instance of technological change may reduce input in any given establishment or process by various combinations of these forms. All of these variable employment effects are important to the local community and to the public employment service, of course, but the most immediately acute adjustment problem is presented when large layoffs occur.

2. The frequently raised question regarding whether automated operations require higher skills appeared in the projects as more a question of the changed composition of the work force of an automated establishment, than of changes in the levels of individual abilities required. That is, in the new operation there were usually fewer of the elementary jobs, and the percentage of skilled workers was thus greater. Work performance requirements did not seem to change significantly, however, even in the maintenance occupations.[3]

3. In the projects, the training required for successful performance in the automated processes was usually minimal. Work force reductions were often based on seniority agreements, and the retained workers took on the new process with a minimum of difficulty.[4]

4. The heavier displacement impact on workers at the bottom of the occupational hierarchy was less a function of their ability than of the fact that simple or mass-production tasks, whether blue collar or white collar, were the ones automated, and those which presented a more obvious target for cost saving.[5]

5. Among the displaced workers were many who faced a constellation of barriers—personal, social, and economic—to reemployment.[6] Frequently, a crucial part of the adjustment process required a flexible attitude on the part of the displaced worker toward the realities of the job market, particularly in terms of the amount of wages he could demand

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[1] *Cudahy Meat Packing Report* (Nebraska Department of Labor, prepublication draft, 1964).

A Large Life Insurance Company Automates (Wisconsin State Employment Service, September 1963).

Progress Report on Automation and Manpower Services Project (Washington: U.S. Department of Labor, Manpower Administration, Bureau of Employment Security, U.S. Employment Service, September 1963, mimeographed).

Three Phases of the Automation Program in a Community (Minnesota Department of Employment Security, October 1963).

Warehousing Firm, Telephone Company, Appliance Manufacturer, Automation Project Report (Pennsylvania Bureau of Employment Security, prepublication draft, August 1963).

[2] See *Progress Report,* op. cit.

[3] *Automation Program Report No. 5* (Colorado State Employment Service, prepublication draft, 1964).

A Large Life Insurance Company Automates, op. cit.

Three Phases of the Automation Program in a Community, op. cit.

[4] *Progress Report,* op. cit.

[5] *Cudahy Meat Packing Report,* op. cit.

A Large Life Insurance Company Automates, op. cit.

Three Phases of the Automation Program in a Community, op. cit.

[6] *Champion Dishwashing Company,* Automation Project Report (Pennsylvania Bureau of Employment Security, prepublication draft, August 1963).

Cudahy Meat Packing Report, op. cit.

Mack Truck Report (New Jersey State Employment Service, prepublication draft, 1964).

and the kinds of work available for him. Reemployment often meant taking a job at a much lower wage, in a different occupation.

In still other instances, placement efforts were extremely difficult because of the failure of displaced workers to accept the fact that they were permanently laid off and their old jobs had vanished.

6. Automation pilot projects conducted by the State employment services do not lend much support to some of the more pessimistic notions about the nature and effects of technological change, particularly those notions pertaining to the "unemployability" of displaced workers. It should be emphasized here that we are not generalizing from experience in the pilot projects, nor are we minimizing the serious nature of adjustment problems facing many individuals and many communities.

The point is that assumptions about the relatively hopeless situation of the displaced worker, even those who are older and unskilled, may not be universally valid. No individual need be arbitrarily relegated to the category of the "unable-to-adjust." Examples from three situations involving workers displaced from meatpacking plants serve to illustrate the point:[7]

a. Intensive interviews of the first several hundred of a group of packinghouse workers recently (August 1964) laid off at a midwestern plant bring to light about 40 occupations, from egg candler to sheet metal layout man, for which individuals in the group may qualify. The problem is to discover those potentials and establish the job market circumstances in which they can be realized.

b. In another meatpacking plant layoff, a followup study about 1 year after the plant closing showed some interesting data concerning employment status of "older" workers and workers occupationally coded "unskilled." This study showed the reemployment success rate of displaced workers by occupational groupings. White-collar occupations—professional, managerial, and clerical groups—showed 80 percent reemployed. The second most successful occupational groups were "skilled" and "unskilled" workers, both of which showed 68 percent reemployed. The reemployment success rates of "service" and "semiskilled" workers was lower than the 68-percent figure for "unskilled" workers—a 64 percent reemployment rate for "service" workers and only 59 percent for "semiskilled" workers. The data imply that the semiskilled experienced the most difficulty in reemployment, and the unskilled did as well as the skilled.

c. In addition, the same followup study showed the average age of the total group of displaced workers as 50 years, and the average age of those workers unemployed at 51 years. In still a third case involving displaced meatpacking workers, there was no significant difference between men aged 45 and over (so-called "older" workers) and men of all ages in terms of employment status, when surveyed a year after layoff. For men as a whole, 63.7 percent were employed at time of followup, while for those 45 and over, the corresponding figure was 63.6 percent. In these two layoffs, if age did exist as a barrier to reemployment, the barrier was apparently overcome.

In closing this part of the discussion, it is appropriate to point out that, given a high level of effective demand, the application of existing techniques of job market analyses, interviewing, aptitude testing, and counseling aimed at overcoming barriers to reemployment can be effective in facilitating the adjustment of many individuals to changing job market demands. At the same time, however, it is recognized that a viable manpower agency must continue to assess the effectiveness of long-recognized techniques and experiment with different, imaginative, methods of easing the adjustment process. For a considerable number of individuals, adequate employment adjustment can be facilitated by occupational and basic education training.

RETRAINING

In this country the major publicly fostered retraining program is the one provided for in the Manpower Development and Training Act, which was passed in 1962, and in its more recent amendments. The act provides in general that training may be given to unemployed persons in occupations for which there is reasonable expectation of employment. The State employment services select the trainees and make training-needs surveys to discover the occupations for which training should be given. The State vocational education agencies develop curricula and conduct the training. Trainees receive allowances approximately equal to unemployment insurance benefits. Throughout the country, over 6,500 projects for about 300,000 trainees have been approved through November 1964.[8]

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[7] *Armour Plant Closing—Sioux City, Iowa* (Iowa State Employment Service, December 1963, intra-agency memorandum).
Cudahy Meat Packing Report, op. cit.
Yvonne S. Karbowski, "Omaha's Response to Automation Layoffs," *Employment Security Review,* Vol. XXIX, No. 7 (July 1962), pp. 34–36.

Information about the nature and operation of the Manpower Development and Training Act is readily available from the U.S. Department of Labor,[9] but three features of it are especially noteworthy in the context of this discussion.

One is the so-called multioccupational training project, which includes basic education. This feature of the act's operations is aimed at those workers whose training potential is inhibited by educational deficiencies that make them less able or unable to benefit from vocational training. This type of training can be operated on a citywide or statewide basis, with area training centers, and in the context of a comprehensive analysis of occupational trends and needs. A total of 72 weeks of training is available in these projects, of which not more than 52 weeks may be vocational. [Ed. Note: The MDTA was amended April 26, 1965, to permit 104 weeks of training, both in regular projects and in projects combining basic education instruction and occupational training.] The basic education training is designed to bring the trainee's competence in reading, writing, and arithmetic up to the sixth-grade level, and may precede or parallel the vocational training. An illustration of this type of training activity is one covering 3,000 trainees in 44 counties in eastern Kentucky, where many workers have been displaced from coal mining jobs by automation and technological change. These trainees are getting up to 12 weeks of basic education in reading, writing, and arithmetic, plus vocational training in such occupations as metalworking machine operator, building maintenance man, auto body repairman, television serviceman, automobile mechanic, combination welder, and cook.

A second specially noteworthy feature of the act is one involving youth. The training for young people is broad-ranged, including orientation to and motivation toward the world of work, plus basic education, in addition to the provision of a vocational skill. There is also included a follow-up after placement on a job, to assure good vocational adjustment. Special youth projects for over 55,000 individuals have been approved throughout the Nation, and others are being developed.

In connection with both of these special mentions of particular Manpower Development and Training Act activities, it should be observed that they are concerned with the work-adjustment processes of individuals who may become chronically unemployed if their employment problems are not dealt with specifically. Some of these people are displaced from their accustomed occupational environments, and others are new entrants to the labor force with no ready or clear way to become a productive part of it.

One of the 1963 amendments to the Manpower Development and Training Act, also worthy of special mention in a consideration of individual adjustment processes, is the one to develop pilot projects designed to assess "the effectiveness in reducing unemployment of programs to increase the mobility of unemployed workers by providing assistance to meet their relocation expenses." While some countries have relocation programs in successful operation, such programs have not really been tried in the United States, and the current plan is experimental in nature. If it proves satisfactory, and if the Congress is convinced of the national utility of relocation assistance, another adjustment program will be available to unemployed workers. The experimental program envisages relocation activities in about a dozen areas.

ADVANCE NOTICE OF LAYOFF AND TECHNOLOGICAL CHANGE

The next manpower adjustment program to be described in this discussion includes and yet goes beyond concern with automation displacement. This activity is often referred to as the "early warning" program but its major constituents are reporting of mass layoffs, with advance notice, and public employment service actions on them.

The mass layoff advance notice activity evolved through the early step of a survey of employer willingness to give advance notice to the public employment service of production changes that would affect employment.[10] Employers in two labor areas were asked whether they would:

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[8] Includes institutional and on-the-job training.

[9] *Manpower Research and Training Under the Manpower Development and Training Act* (Washington: U.S. Department of Labor, March 1964).

(1) Communicate plans for technological changes to the local employment office as early as 12 or 6 months prior to the effective date of the change;

(2) Assume the initiative in supplying this information, or supply it if it were solicited by a representative of the employment service during one of his regular visits;

(3) Engage in a cooperative effort with the local public employment office to analyze existing jobs and new jobs to be created by technological change and to investigate the skills and secondary occupations of the members of the establishment's work force;

(4) Identify new occupations likely to appear in their industry during the next 5 years;

(5) Engage in a cooperative effort to inform educators of the kinds of training needed by workers entering new occupations in the near future.

A majority of the employers in the survey expressed a willingness to give advance notice of technological change to the local employment office, but they varied in their willingness to participate in the various phases of the program described above. There was, for instance, a disposition to give advance notice only in response to inquiries. Some managements felt that their own personnel departments were better qualified than the staff of the local employment office to analyze existing and new jobs and identify the retraining potential of workers. Most firms were ready to notify workers of possible displacement and advise them to utilize local employment offices in finding new jobs or occupations for which they might be retrained. There was also evidence that some employers were concerned that disclosures of information on planned innovations would endanger their competitive positions.

In mid-1962, the U.S. Employment Service was ready to inaugurate its program. In close succession, three approaches for timely action on technologically generated problems of manpower supply and demand were established, using respectively, the employer relations program, the occupational analysis program, and most important and of the greatest operating utility, a new program termed the mass layoff reporting program.

Under the employer relations approach, employer relations representatives, who regularly visit employers to find out their manpower needs and to offer the services of the public employment office, are now instructed to enlarge the scope of their inquiries to include information about planned changes in technology, and the probable employment effects.[11] They may then enlist the cooperation of the employer for a special program in conjunction with the local employment office to assist in placement efforts on behalf of any workers who might be laid off, and to use the local office to recruit workers in hard-to-fill occupations. The special program on behalf of laid-off workers includes intensive efforts to assist the workers in obtaining new jobs. They are interviewed in depth to develop all information related to their qualifications. Some may be given aptitude testing and occupational counseling, and possibly referred to training to renew an old skill or build a new one. Job development efforts augmenting local office resources with various community resources, such as chambers of commerce, can be undertaken. This effort represents an updating of the employer relations program that is reflected in actions at the local level. It is not tied into a special reporting procedure, and, thus, instances of its use do not come formally and regularly to the attention of Federal-level officials and national statistics are not compiled.

A second "system" is based upon the U.S. Employment Service's program of occupational analysis, a research program that has led to the publication of the *U.S. Dictionary of Occupational Titles*, which describes and classifies over 24,000 jobs. In the course of work to gather current occupational information, the analyst may encounter instances of the introduction of new technology.[12] To expedite the use of this information throughout the public employment service, occupational analysts are requested to submit special reports on changed methods and processes. These reports are reproduced and given general distribution to increase the level of job knowledge available at the local employment service level.

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[10] E. E. Liebhafsky, "Improving the Operation of Labor Markets Through an Employment Service Advance Notice System," *The Southern Economic Journal*, Vol. XXIX, No. 4 (April 1963).

[11] *Employer Attitudes Toward Advance Notice of Technological Change* and *Methods for Establishing Advance Notice of Technological Change from Employers* (Washington: U.S. Department of Labor, Manpower Administration, Bureau of Employment Security, U.S. Employment Service, June 1962 and August 1962, respectively).

[12] *Information on New Automation Situations Observed by Occupational Analysts*, U.S. Employment Service Program Letter No. 1346 (U.S. Department of Labor, Manpower Administration, Bureau of Employment Security, September 1962, mimeographed).

The major approach to advance manpower action is the mass layoff reporting program. This program's emphasis is on obtaining notice in time to allow for planning of manpower services at the local level, but it is tied to a reporting system so that experience with it is available at the Federal level. State employment service agencies are asked to report actual or anticipated nonseasonal layoffs of 100 or more workers, and to describe the actions taken or planned by the local employment offices concerning the layoffs. The reports, prepared at the local office, show such detail as number of workers by occupation, and the reason given for the layoff. A separate report is prepared for each layoff. Special manpower actions, with Federal assistance, are undertaken when the nature of the layoff appears to require it.

The primary usefulness of the reports received at the Federal level is that they bring attention to unemployment trouble spots, and indicate the extent of mass layoff activity in the 50 State agencies. From the reports being received and from direct local followups, it is evident that there is wide use of the reports at the local level for operations planning and interarea recruitment. The reports also serve as a means, at the Federal level, to review local office plans for dealing with mass layoffs and to identify situations suitable for or warranting special worker services.

During the first 24 months (September 1962–August 1964) of the U.S. Employment Service's mass layoff reporting program, State employment service agencies reported slightly over 800 permanent layoffs involving about 250,000 workers.[13] Over half of these layoffs were from plants that closed. About 58 percent of the 800 layoffs were reported to public employment service offices in advance of actual layoff, although in many cases the amount of advance notice was very slight. In over one-fourth of the permanent layoff cases, local employment offices had undertaken intensified assistance efforts for the displaced workers. These efforts included working with local economic development agencies, stepped-up job development activities, the utilization of training opportunities such as provided under the Manpower Development and Training Act, and fullest use of interarea recruitment facilities.

Regular local office services were generally afforded the laid-off workers in all other instances. These included interviewing, counseling, testing, and referral to training and jobs. The difference between "regular" and "intensified" services to workers is entirely a matter of the nature of the individual layoff problem and of the local labor area. The decision to use either one is usually made at the local level.

The mass layoff program is dynamic and still evolving. Further expansion and modification can be expected, in accordance with the needs of the job market. The guiding principle will remain the same: The U.S. Employment Service will secure advance information on local job market changes and take positive action to facilitate the smoothest possible manpower transitions.

ACTION ON MASS LAYOFFS

In real life of course, when a mass layoff does occur, it occurs in a community—and as has been said before, the revealed impact of technological change, in human rather than statistical terms, is in the local community—at the level of the individual worker, occupation, and plant. Its minimum definition is that people entering the job market for the first time cannot find jobs readily, that disadvantaged individuals encounter a host of barriers to reemployment and drift into long-term unemployment, and that those whose reemployment potential is relatively high may need a variety of aids—from counseling and training to information about the job market—to make their personal planning more sophisticated and effective.

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[13] These data are not indicative of total layoffs in the United States during the 2-year period. The figures relate to permanent nonseasonal layoffs involving 100 or more workers, which came to the attention of public employment service offices. A further limitation is that not all State employment service agencies started the reporting program in September 1962.

This area of the problem lies between the employment adjustment procedures afforded by labor-management policies and programs such as separation pay and early retirement, and public policy programs such as tax reduction, unemployment insurance, and youth employment activities.

Typically, this intermediate area is reflected in a community in which employment disorientation has taken, or is taking, place. The adjustment measures involve a comprehensive utilization of community resources, public and private, with the local employment service as the community manpower agency.

While each mass layoff situation has unique characteristics, so that a formula approach is not possible, most appear to have common attributes as far as employment adjustment actions are concerned. Important among these are:

1. The marshaling of community resources, under such specially established organizations as a Citizens Reemployment Committee, or a Mayor's Committee on Automation. These committees are widely representative of community organization and facilities, and have two main functions: (1) reemployment of unemployed workers; and (2) providing new job opportunities for the community. They use the public employment service as their operating arm, and draw heavily upon its staff resources and its information about labor supply and demand.
2. Intensive evaluation of the employment potentials, and the training and other needs of the unemployed workers. The employment service has found that some groups of workers commonly assumed to be very low on the reemployability scale may represent quite an array of employment possibilities. For example, a large group of packinghouse workers, averaging 48 years of age, 7 grades of education, and having an average plant tenure of 17 years were found to be qualified, as a group, for about 100 different occupations.[14] A varying, but unusually smaller, portion of these face a complex of barriers—economic, social, and personal—to reemployment.
3. Intensive evaluation of the labor demand situations, existing and future. The public employment service assesses the job market and its needs and trends. Labor area analysts regularly conduct both long- and short-term surveys, and have current knowledge of growing or declining employment possibilities.
4. Saturation job-finding campaigns, and interarea recruitment. At a layoff in Sioux City, Iowa, the employment service started its job-finding operations with letters to 2,000 employers in the immediate area and 500 employers throughout the country, with attached lists of the occupations for which the unemployed workers were qualified.
5. Establishment of training programs. In both Sioux City and another large layoff in South Bend, Ind., area training centers were established jointly by the employment service and vocational school people. These training centers provide a range of training from basic education to specific vocational training.[15]
6. Integration of communty agencies. In the Omaha, Nebr., effort the Central Welfare Council was represented on the Mayor's Automation Committee, and every applicant to any welfare agency was checked out with the employment service.[16]

A POSITIVE MANPOWER POLICY IN A DYNAMIC ECONOMY

In closing, it should be stated that achieving deeper insights into the impact of technological change upon the individual and of the resultant adjustment process is, of course, vital for more effective manpower policies. More information-gathering programs to obtain the necessary data are needed as well as more intensive analysis of existing data and experience. As can be inferred from the preceding discussion, the varying influences of automation on the job market raise questions concerning important aspects of the individual adjustment process which remain unanswered or only partially answered.

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[14] *Cudahy Meat Packing Report*, op. cit.

[15] Lewis F. Nicolini, "The South Bend Story, The Shutdown," and Harold Kuptzin, "The South Bend Story, The Reemployment Program," *Employment Service Review*, Vol. XXIX, No. 3 (March 1964), pp. 36 and 37, respectively.

[16] *Cudahy Meat Packing Report*, op. cit.

As is so often the case, however, policy prescriptions and action programs cannot wait for universal findings about the problems at hand. The minimum requirements of an institution such as the public employment service for a positive manpower policy include:

(1) A high level of effective demand.

(2) A division of the total problem into manageable units.

(3) Fullest utilization of existing resources with problem-solving capabilities.

(4) Recognition that simple cause-and-effect relationships do not exist, and no one action is a panacea.

(5) Recognition that any general action, such as demand stimulation, may be inhibited by inefficiency in the local job market in the form of inadequately trained labor, inadequate vocational and general education, and restrictive practices of concentrations of economic power. These must be dealt with realistically.

(6) The problem areas immediately to be faced are: (a) Jobs for new entrants into the labor force; (b) jobs for those experiencing wholesale displacement; and (c) concentrated measures to solve the employment problems of the long-term unemployed.

The requisites of employment and manpower services, existing and desirable, that are needed for effective adjustments in a job market continuously in flux, are set forth in detail in E. Wight Bakke's *A Positive Labor Market Policy*, Charles E. Merrill Books, Inc., 1963.

In a real sense Dr. Bakke's book is definitively related to today's topic "The Labor Force Adjustment of Workers Affected by Technological Change." The manpower problems implicit in the topic are part of what might be described as an ecological system in which the interrelationships are so extensive that attempts at separate consideration run the danger of presenting a distorted view. Perhaps this discussion can be concluded through further reference to two publications of great relevance to the interests of this meeting. One is the *Employment Security Review* for June 1963, which is a theme issue on the United States Public Employment Service in the Nation's Job Market 1933–1963. The second is a committee print of the U.S. Senate Committee on Labor and Public Welfare, prepared by its Subcommittee on Employment and Manpower. The print is titled "Toward Full Employment: Proposals for a Comprehensive Employment and Manpower Policy in the United States." Along with Dr. Bakke's book, these are recommended as major documents for consideration of manpower adjustment problems.

IMPLICATIONS FOR GOVERNMENT-SPONSORED TRAINING PROGRAMS IN THE U.S.A.

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THE IMPACT OF technological development is most often described in terms of human displacement, changing skill and knowledge requirements, or changing concepts of manpower utilization. Effective manpower utilization during a period of technological change requires a fluidity within the labor force in order to match manpower requirements and resources. Thus education and training become identified as the manpower utilization catalyst. Economic and manpower planners seeking the balance or adjustment of the manpower resources to meet the evolving skill and knowledge requirements therefore assume the capability of training personnel, in both the public and private sectors of the economy, to bring about the necessary changes in individuals to match work force requirements.

The nature of the technological revolution taking place over the world is amply covered elsewhere in this conference. In the context of this paper, however, it may be useful to mention the three major trends in this revolution—as they are described in the 1964 *Manpower Report of the President*.[1] *First*, there are the advances and innovations in information-handling technology—electronic data processing, instrumentation and control, numerical control, and advances in communication. *Second*, there is the substitution of physical energy for human labor in industrial activities, including improvements in machinery, mechanization of materials handling, developments in metal processing, and innovations in transportation and in power generation. *Third*, there is the economic and social impact of new materials and products (e.g., plastics, synthetics, transistors) on many industries.

All of these innovations require the acquisition of new knowledges and skills by the work force, and in varying degrees force the displacement of workers who do not have or cannot acquire these knowledges and skills. That the whole educational, training, and retraining apparatus of our society must be tuned to these ever-changing needs is universally understood.

Because the impact of automation and technology brings about change in the occupational matrix, on the one hand, while at the same time it displaces workers previously skilled in declining occupational categories on the other, implications for education and training are most complex. Training efforts thus must be multifaceted. For the short run, retraining programs must be developed for the displaced—the unemployed as well as for the out-of-school, out-of-work, and occupationally untrained youth; while for the long run, educational and training systems, both public and private, must be regeared through profound curriculum changes in order to prepare today's youth for tomorrow's jobs through meaningful, up-to-date educational experiences.

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[1] *Manpower Report of the President and A Report on Manpower Requirements, Resources, Utilization, and Training* (Washington: U.S. Department of Labor, March 1964).

NOTE: At the time this paper was presented, Dr. Walsh was serving as Deputy Director, Office of Manpower, Automation and Training.

In setting the parameters for this discussion it was recognized that, from the point of view of the United States, the great bulk of the vocational education of our youth will continue to be achieved through the regular educational systems, both public and private. Similarly, the great bulk of the retraining of workers will continue to be achieved by business and industry itself through employee training programs. However, there remains a large and growing segment of unmet training needs, much of it spurred by the technological revolution, which calls for "government-sponsored training" in order to reposture the unemployed and the disadvantaged so that they may cope with the changing world of work.

The process of education and training is inextricably meshed with governmental policy and process. In the United States, Federal funds have been appropriated for the promotion and development of vocational and technical education, for the establishment of manpower research and development programs, for area redevelopment programs which include manpower training, and a host of other activities that provide for the development of human resources. All have the same objective—the improvement of manpower utilization. For the most part, all seek to alleviate the results of inadequate preparation for the evolving world of work—the problems of unemployment and underemployment.

SUPPORT FOR GOVERNMENT-SPONSORED PROGRAMS

Manpower-oriented programs of education and training have been federally supported in the United States over a considerable period of years beginning with the Morrill Land-Grant Act of 1862 through the Vocational Education Acts of 1917 and 1946 and others. Direct federally sponsored programs (other than programs during periods of national emergency—World War II, etc.) had their beginnings in the current decade with the passage of the Area Redevelopment Act in 1961 (ARA)[2] and the Manpower Development and Training Act of 1962 (MDTA)[3] in response to structural problems in the unemployment arena.

Congressional support for such programs was significantly nonpartisan, underscoring the universal recognition of the need for such programs. The wisdom of such action is evidenced most clearly in the thrust of programs and the favorable outcomes of the Manpower Development and Training Act, which has in a few short years seen the emergence of over 5,000 training programs serving a quarter million unemployed individuals and providing training in over 500 occupational categories running the gamut of available jobs in all categories.[4] Most significantly, those who have completed the training programs and secured employment have found themselves working at higher skill levels and in jobs less vulnerable to future technological impact.

The year 1963 was characterized by President Johnson as a most important year in the history of education and manpower development. Congress passed amendments to the Manpower Development and Training Act, strengthening its impact on the disadvantaged and displaced and at the same time passed legislation broadening the impact of public vocational education as well as improving higher education facilities. All demonstrate rather conclusively the acceptance of the principle of Government aid and sponsorship of training and retraining of American youth and adults to meet the challenge of the times.

The following examples tend to underscore the attitude of support of Government aid for programs aimed at improving the posture of individuals to cope with a changing world of work.

In a survey of school superintendents throughout the country conducted in 1963 by the National

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[2] Public Law 87–27, May 1, 1961.

[3] Public Law 87–415, Mar. 15, 1962, as amended by Public Law 87–729, Oct. 1, 1962; as amended by Public Law 88–214, Dec. 19, 1963. [Ed. Note: The act was further amended on April 26, 1965 by Public Law 89–15.]

[4] Statistics reflect the Manpower Development and Training Act program level of November 1964.

Education Association Research Division the following significant response to one of the questions was obtained:

Question: Should Federal funds be provided for local programs of public school adult education?

Total replies: 687

Opinion	*Superintendents of Systems*	
	With programs	*Without programs*
Percent distribution	100.0	100.0
Yes	70.1	58.4
No	29.9	41.6

In a nationwide evaluation of the MDTA program conducted by the Office of Manpower, Automation and Training late in 1963 and early in 1964, the evaluation team found that the principle of retraining the unemployed with Government aid is accepted throughout the country. There was little or no expressed feeling on the part of civic leaders, business and industry leaders, employers, labor leaders, or others that such programs are a waste of money or are temporary in nature and will not be needed in the future. Even in communities where the prevailing civic and business opinion was opposed to Federal aid, an exception was made for this program.

LIMITATIONS ON POTENTIAL EFFECT OF GOVERNMENT-SPONSORED TRAINING

The necessity for vocational and manpower training programs sponsored by the Government is obvious. Only the central government has the machinery to assess the relationship of the need for skills and abilities and the potential labor supply throughout the country in this period when shifts of industrial capacity ignore State lines. In vocational education, the Federal Government must assist the States in planning systems which mesh with the systems of other States and are geared to meet national as well as local needs. A coordinated, integrated system for retraining adult workers which matches nationwide needs to nationwide supply is essential. Also, there are groups which it is uneconomical for industry to train, and which can only be reached to a substantial degree by Government-sponsored programs—particularly the underprivileged and "hard-core" unemployed.

There are dangers, however, in the wholehearted acceptance of Government-sponsored programs and the enthusiasm which they generate. There is, for one, the danger that the public will expect too much from them. There is the danger that the predominant role of industry in doing its own training and retraining will be obscured and misunderstood.

There have been numerous cautions from responsible sources against expecting too much from Federal efforts to train the unemployed. For example the report to the Senate of July 1961, on the pending Manpower Development and Training Act bill, advanced such a caution rather pointedly: "A word of caution is necessary. Training for the unemployed is not a panacea for the problem of unemployment or a cure for the malfunction of our economy. Training does not of itself produce jobs, except in extraordinary cases."

In presenting the bill to Congress, Senator Clark felt compelled to make the following remarks at the end of his presentation:

> In conclusion, I stress again that this bill promises no Utopia. Its enactment would not solve the unemployment problem. The bill is not going to result in the retraining of all the citizens of the United States of America. But the bill will result in training and retraining enough to make a really significant start.

Cautionary references regarding the Vocational Education Act of 1963 have been less pointed, except that much comment has been made on the inadequacy of the money appropriated to do the enormous job needed. There is general recognition by educators, however, that a long, hard road lies ahead before vocational education, Government-sponsored or otherwise, can make an appreciable change in the ratio of needs to available skills.

What are the factors limiting the potential of Government-sponsored training programs? How much should be done to counteract these limitations through policy adaptations and changes?

The major limiting factors appear to be the following items outlined below.

Limitations of Capacity of Vocational Education System

One of the principal reasons for the skepticism of informed persons about the capacity of any extensive Government-sponsored training program in itself to make much headway is the well-publicized lack of capacity of the vocational education system in the United States to absorb extensive new adult-training programs. There are cities, and even States, where vocational education has had adequate public support for years, and where educational authorities have planned and achieved plants and staff adequate for teaching the skills needed today. But these are the exceptions. The inadequacies of the vocational education system have been recognized for years, and the experiences of States in trying to carry out the training provisions of the Area Redevelopment Act and the Manpower Development and Training Act focused attention on the inadequate scope of our public vocational education program.

Francis Keppel, U.S. Commissioner of Education, had this to say in an address to the U.S. Chamber of Commerce:

> In the sprawling complex of our modern cities, many of our early vocational schools remain as remnants of the past, as red brick monuments to a day gone by. Remote from the mainstream of modern technology, they are training young people for vocations already becoming extinct. Within the educational community, they are often regarded as institutions for youth who are failing in academic pursuits, as "dumping grounds" for the poorly educated.

The focus on these matters drawn by manpower training programs furnished part of the impetus to Congress to pass the landmark Vocational Education Act of 1963 and the Higher Education Facilities Act of 1963.

It is true, however, that within just the past 2 or 3 years the stimulus of funds for these Government manpower training programs and the attention focused by them on educational inadequacies have brought about an enormous amount of modernization and expansion. What is more important, the giant Federal steps forward in 1962 and 1963 have given vocational educators at State and local levels a new hope for a shining future and have encouraged them to plan for that future with imagination and daring.

Important as these acts are, and significant as the upsurge in vocational training is, it will be years before their full effects can be felt, and by that time the training demands of technology advancing at a breakneck pace will have far outstripped the potential of the 1961, 1962, and 1963 laws. New laws will be passed, but legislation traditionally lags behind social needs. Also, qualified instructors are likely still to be scarce. Thus the limitation on Government-sponsored training programs is expected to continue.

There has been a conscious effort already to adopt existing policies and create new ones to minimize the effects of this situation. In the training under the Manpower Development and Training Act, increased use of private training facilities has been encouraged by congressional actions and the departments have evolved a policy permitting individual referral to on-going training courses. Instructors are often hired from industry, space is often rented, and other expedients are used. However, improvements in vocational training facilities and the availability of instructors stimulated by the Vocational Education Act of 1963 will of necessity be slow.

Limitation in Ability to Keep Up With Technological Change

The tremendous energy generated by the exponential growth of science and technology during the past three decades shows no signs of diminishing. On the contrary, it is expected to continue to grow. Inevitable results of this growth include the rapid obsolescence of systems and products, the increased complexity of tools and products, the burgeoning of new businesses along with the death of old businesses, and the displacement of labor.

In contrast to the dynamic, explosive, ever-shifting picture presented by industry, the process of education is relatively static. It has to be, dependent as it is on public funds and controls and the necessity for establishing standards and continuity. Government-sponsored institutional training in occupations, whether operated directly by the Government, through established schools, or as part of regular school programs, must also be relatively stable. To give one example of why this is so: equipment is extremely expensive, and a taxpayer-supported school cannot expect to buy every year the newest examples of heavy machinery, machine tools, or computers.

This, then, is a limitation on the use of Government-sponsored institutional training programs to meet the challenge of technological change. It is not significant in certain occupations where the basic skills and knowledges remain the same year after year. It does not apply to Government-supported on-the-job training programs, where trainees use the equipment and learn the techniques in actual use at the time of their training. To date, however, such Government-supported on-the-job training programs have had a restricted use.

Obviously, Government-sponsored on-the-job training needs to be strengthened and expanded. Also cooperative manpower training centers in which industry would participate, lend equipment for institutional courses, afford trainees the use of their own equipment at times, and furnish instructors, might give some of the flexible base needed both for regular vocational programs and for the retraining programs. To be most effective, often the areas serviced by such centers would have to cross State lines, thus underscoring the need for Government-supported programs.

Limitations in Trainability of Work Force

The educational demands of jobs in our complex economic and industrial system are becoming greater year by year, even week by week. One has only to look at the "help wanted" ads in newspapers to realize this. The rural agricultural worker and the urban factory worker are being replaced at an ever-increasing pace by the technician, a complex, sophisticated individual with a refined kind of education. To be at home in this mixture of frenzied cybernation and hectic "freed-up" or "leisure" time, a worker must have an education at a level which would have seemed astonishingly high only 50 years ago.

It follows that to be trained for remunerative work in this society, a person must have basic education which will enable him to absorb the training and be acceptable to employers. How high should this be? It varies with the job, but, generally, the technician level requires post-high-school training, the skilled-worker level and nearly all white-collar jobs require the equivalent of a high school education as a base, while those jobs that are left in the semiskilled category require at least some high school education. Yet in 1962, 8.2 million persons in this country aged 25 and over had completed less than 5 years of schooling. In 1960 only 41.7 percent of the population 15 years of age and older had graduated from high school. Of course, the age cohort now in school will fare much better in the long run.

Valiant efforts have been and are being made through existing manpower training programs to overcome this handicap. Basic literacy units are part of many courses. Congress in 1963 authorized 20 extra weeks of training, specifically for the purpose of basic education, to be added to the 52 weeks already authorized by the Manpower Development and Training Act. But this only makes 72 weeks, most of which have to be devoted to occupational training. This points up one of the most serious limitations of Government-sponsored training programs—for that part of the population which needs training the most, there simply is not enough time to do the job properly. [Ed Note: The MDTA was amended on April 26, 1965 to permit 104 weeks of training, both in regular projects and in projects combining literacy instruction and occupational training.]

Limitations in Employment of Graduates of Training Programs

Graduates of standard 2-year vocational courses offered throughout the country by vocational schools, trade and technical institutes, and junior colleges usually have little difficulty in finding training-related jobs, provided they have been trained in occupations in demand and in programs planned with the advice of the business-industry community. On the other hand, similar programs preparing trainees for entry into declining or obsolescing occupations suffer less than acceptable placement records.

Similarly, programs developed under the Area Redevelopment Act and the Manpower Development and Training Act with the attendant requirement that there must be reasonable assurance of employment in the area served by the training program maintain good placement records as attested to by the current high placement rate. But what of the unemployed or the disadvantaged residing in areas of declining job availability?

Here the need exists for relocation benefits to insure the necessary mobility of individuals to places where the jobs are.

Only Government-sponsored programs can accomplish such mobility to any practical degree. Under the impetus of amendments to the Manpower Development and Training Act such relocation programs are already being explored, and under research-oriented programs of experimentation and demonstration clues will be found to successful accomplishment of this means of matching men and jobs, with training becoming a facet at either end of the relocations. Needed for such effective relocation programs is a clearing house of job vacancies and manpower development programs coordinated from the Federal level.

REQUIREMENTS FOR EFFECTIVE GOVERNMENT-SPONSORED TRAINING

Current experience has proven the need for expanded and more sophisticated programs of Government-sponsored training to meet the needs of the economy and to meet the needs of disadvantaged or displaced individuals that result from the impact of technology in transition. In order to provide for the kind of broad-gauged program demanded by the shifting patterns of employment and the changing concept of work life, a number of steps must be taken.

1. Manpower Research and Experimentation

Continuing studies of the impact of technology on people and occupations, especially in the relationship between them, must be intensified and findings applied to experimental programs to determine adequate, effective, and efficient means of matching tomorrow's man to tomorrow's job.

2. Demonstration Manpower Programs

In the light of inadequacies in facilities, equipment, and trainers in traditional manpower development settings, there must be a continuing demonstration of the variety of ways in which the disadvantaged and the displaced can be repostured for effective participation in the work force. In short, new pathways to employability must be demonstrated in order to relieve an already overburdened institutionalized program when needs are burgeoning.

3. Business-Industry Participation

Expanded utilization of the business-industry community in Government-sponsored programs can make possible the kind of training environment needed to prepare individuals for new occupational categories as they emerge. Such partnership for progress can help cut down the leadtime between program planning and program implementation that traditionally hamstrings the development of institutionalized programs.

4. Manpower Development and Utilization Committees

Required at Federal, State, and community levels are *active* lay committees sufficiently concerned with manpower problems to work for effective early warning systems, so necessary for the functioning of an active labor policy throughout the Nation. Just as we accomplish the generation of effective educational systems through the application of democratic practices in school board operation, so we can accomplish effective manpower systems to cope with the impact of automation and technology by drafting community leadership for manpower planning and policy development to give direction to the elements of an active manpower program.

5. Manpower Evaluation and Analysis

Required is a nationwide program to evaluate the accomplishments, the shortcomings, and the gaps in our manpower programs in order to provide effective analysis to guide the redirection and intensification of action programs to meet evolving needs. Through such professionalized services, community manpower groups can steer a course toward quality programs avoiding the pitfalls of inadequate planning and programing.

6. Manpower and Automation Clearinghouses

To adequately attack the problems that emerge in the manpower arena as a result of the impact of automation and technological change, there is required an effective data-gathering, data-retrieval, and data-dissemination system which will provide up-to-the-minute information, program parameters, planning guidance, and research and experimental findings and will build flexibility into Government-sponsored programs so that they can respond fluidly to the changing demands.

7. Flexible Manpower Legislation

In order to cope with the ever-changing demand for program planning, implementation, evaluation, and adjustment in a variety of areas running the gamut of research, experimentation, demonstration, relocation, individual counseling and evaluation, and training and retraining, there exists the ever-growing need for broadly drafted, Government-supported legislation. This should include provisions for continuous funding at levels commensurate with program demands, in order that required programs can be made functional rather than be limited to only those which can be squeezed into the framework set by dollar ceilings.

To the degree that the above criteria are met, Government-sponsored training programs will be able to measure up to the demands that are being set by the impact of automation and other technological change.

Appendix A

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Appendix B

Following is a list of the technical papers presented at the OECD Conference on the Manpower Implications of Automation, held in Washington, D.C., December 8–10, 1964.

"Technological Change, Productivity, and Employment in the United States."
Mr. Leon Greenberg, Assistant Commissioner, Productivity and Technical Developments, Bureau of Labor Statistics, Department of Labor, U.S.A.

"Technological Change, Productivity, and Employment in Canada."
Mr. J. P. Francis, Director, Economics and Research Branch, Department of Labour, Canada.

"The Pace of Technological Change and the Factors Affecting It."
Dr. Seymour L. Wolfbein, Director, Office of Manpower, Automation and Training, Manpower Administration, Department of Labor, U.S.A.[1]

"Effects of Changing Industrial Structure on Occupational Trends."
Dr. G. Schonning, Assistant Director, Economics and Research Branch, Department of Labour, Canada.

"Effects of Technological Change on Occupational Employment Patterns in the United States."
Dr. Ewan Clague, Commissioner, Bureau of Labor Statistics, Department of Labor, U.S.A.

"Effects of Technological Change on the Nature of Jobs."
Dr. Louis Levine, Director, U.S. Employment Service, Manpower Administration, Department of Labor, U.S.A.

"European Experience with the Changing Nature of Jobs."
Professor E. R. F. W. Crossman, Oxford University, U.K.[2]

"Variety in Adaptation to Technological Change: The Contribution of Collective Bargaining."
Professor Arnold Weber, University of Chicago, U.S.A.

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[1] Dr. Wolfbein is now Special Assistant to the Secretary of Labor for Economic Affairs.

[2] Professor Crossman is currently Associate Professor of Industrial Engineering at the University of California (Berkeley).

"Methods of Easing Automation's Impact on Workers—A Report on Recent Experience in the Steel Industry."
Mr. Marvin J. Miller, Assistant to the President, United Steelworkers of America, U.S.A.

"Advance Planning for Manpower Adjustments at the Plant Level and the Role of the Manpower Consultative Services."
Mr. G. G. Brooks, Director of Manpower Consultative Services, Department of Labour, Canada.

"The Labor Force Adjustment of Workers Affected by Technological Change."
Mr. Robert C. Goodwin, Administrator, Bureau of Employment Security, Manpower Administration, Department of Labor, U.S.A.

"Mobility, Methods of Job Search, Attitudes, and Motivation of Displaced Workers."
Dr. Harold L. Sheppard, W. E. Upjohn Institute for Employment Research, U.S.A.

"Implications of Automation for Education."
Dr. Virgil M. Rogers, Director, Education Project, National Education Association, U.S.A.

"Implications for Training Programs in Industry."
Mr. Ralph Boynton, President, American Society for Training and Development, U.S.A.

"Implications for Government-Sponsored Training Programs in the U.S.A."
Dr. John P. Walsh, Deputy Director, Office of Manpower, Automation and Training, Manpower Administration, Department of Labor, U.S.A.[3]

"Implications of Automation for Government-Sponsored Training Programs in Canada."
Dr. W. R. Dymond, Assistant Deputy Minister of Labour, Canada.

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[3] Dr. Walsh is now Assistant Manpower Administrator, U.S. Department of Labor.

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